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Accident to Gates of Lock 22, Welland Canal, near Thorold, Ont.

By Emile Low*

One of the most serious accidents in the history of the Welland Canal occurred about 3:30 p.m. Thursday, June 20, 1912, at Lock 22, near Thorold, Ont., Canada. A steamer bound up from Lake Ontario to Lake Erie, and just entering Lock 22, ran into the upper gates of the lock and opened them; the subsequent rush of water dismounted both the upper and lower gates of the lock, wrecked the steamer and a number of scows in the canal below, and drowned three boys who were near the canal bank at the time.

The numbering of the Welland Canal locks begins with No. 1 at Port Dalhousie on Lake Ontario and extends southward to Port Colborne on Lake Erie. The lock at Port Colborne, No. 26, is a guard lock, and Lock 25 is at the northern end of the long Lake Erie level, which ends a short distance south of Thorold. At the latter point the descent to Lake Ontario begins, skirting the escarpment between the two lakes.†

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†See article on new breakwater at Port Colborne, Welland Canal entrance, Eng. News May 15, 1902, p. 382, by E. Low.

On June 20 a Canadian survey steamer, the "La Canadienne," was proceeding up through the Welland Canal on an inspection trip from Lake Ontario points to Duluth. The steamer is a steel vessel about 150 ft. long, 30 ft. in beam and drawing about 10 ft. of water. It had just passed out of Lock 21, some 800 ft. below, and was entering Lock 22. The lower gates of this lock were open and were within the gate recesses, being held in place by the automatic gate hook. Along the lock walls are concrete snubbing posts; every vessel passing through the lock must have two men to attend to the snubbing line, one end being made fast to the vessel or to its capstan forward, and the other end to one of the snubbing posts. It seems that at the time of the accident the lower end of the snubbing line was in place around the snubbing post on the lock wall, but its other end had not been securely enough fastened to the vessel, so that it did not hold as the vessel moved forward. The result was that the headway of the steamer was not checked and the vessel struck the left-hand leaf of the upper gate, opening the gate and allowing the water of the upper level to pour into the empty lock chamber.

The inrushing water lifted the upper gates off their sockets and carried them with the steamer into the canal below the lock. At the same time, the holding mechanism of the lower gates being too weak for the rushing water, these gates also were torn from their fastenings and followed the steamer and upper gates into the canal below.

The boys who were drowned by the wave of water had been playing on the bank of the equalizing basin to the left of the canal just below Lock 22. Two out of five succeeded in saving themselves, but three were carried away.

The three views herewith, Figs. 1 to 3, show the appearance of the canal prism

Fig. 1. Looking Downstream from Lock 22 to Lock 21. Steamer "La Canadienne" Stranded on Right Bank of Canal.

(Four gates of Lock 22 are lying in canal prism; scows engaged in removing them. Equalizing basins at left of canal. Water drawn from canal prism.)

Fig. 2. View from Waste Weir across Equalizing Basin toward Lock 21.

(Canal with stranded steamer at right. Niagara escarpment in distance.)

Fig. 3. Lower Gates of Lock 22 Replaced.

(One of upper gate leaves is lying in foreground.)

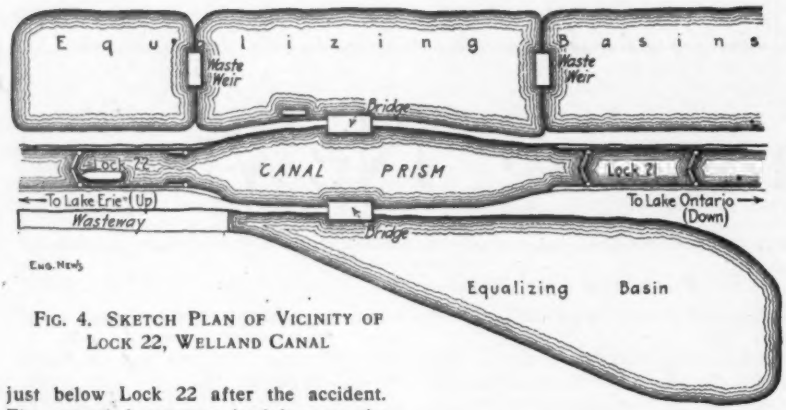

FIG. 4. SKETCH PLAN OF VICINITY OF LOCK 22, WELLAND CANAL

just below Lock 22 after the accident. The stranded steamer is lying on the right bank; its side was damaged, possibly by striking the bank, and the vessel sank. At the time the photograph was taken, the canal prism had been emptied as an aid in finding the bodies of the drowned boys and for recovering the displaced lock gates of Lock 22. These gates are seen lying on the banks in the view Fig. 1, while in Fig. 3 the lower gates are shown after they were put back in place, one of the upper gates still lying on the canal bank in the foreground.

The sketch plan Fig. 4 exhibits the locality.

A device for minimizing the risk of accident in case of boats striking the lock gates has been installed at Lock 24, and is being fitted to Lock 21. This is the Gowan Lock-gate Safety Appliance. It is sketched diagrammatically in Fig. 5, where its action when a boat strikes one leaf of the gate is represented; the photograph Fig. 6 shows it applied to a lock gate.

The device consists of two large horn castings, one on each gate-leaf, each having the face abutting against the other leaf shaped to the arc of motion of that leaf. When one leaf is pushed back, the

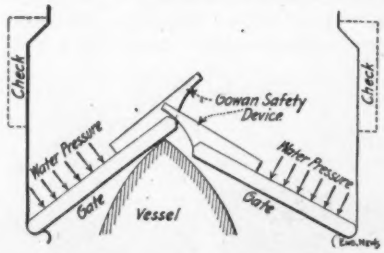

FIG. 5. DIAGRAMMATIC SKETCH OF GOWAN LOCK-GATE SAFETY APPLIANCE AS FITTED TO A PAIR OF LOCK GATES

(The gate leaves are represented as forced out of miter. Not to scale.)

other leaf would, without this device, be forced downstream by the water pressure, and lacking the abutting pressure of the miter the leaf would be wrecked. The safety device prevents such action in case of small motions, and guides the leaves back to proper miter. It also helps to secure true mitering whenever the gates are closed.

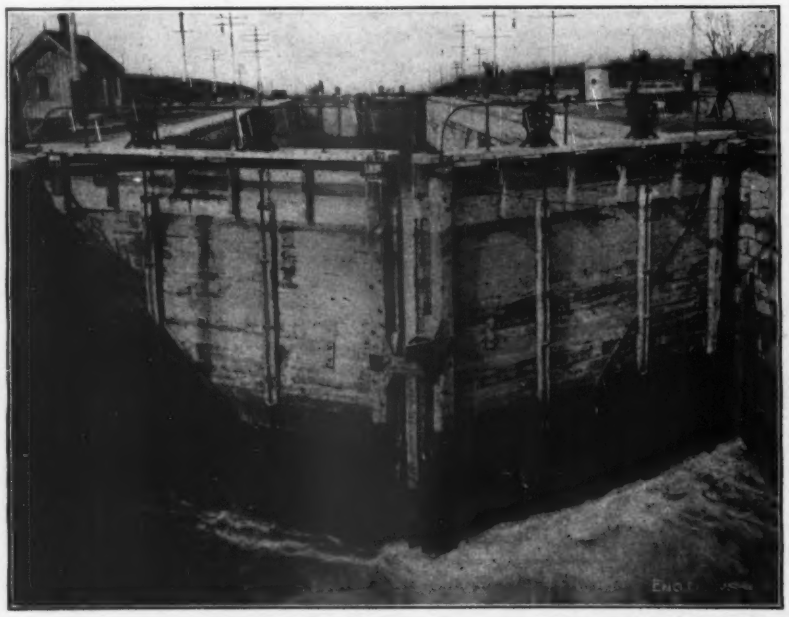

FIG. 6. VIEW OF GOWAN SAFETY APPLIANCE ON A LOCK GATE

The New Panama R.R.—The section of the Panama R.R. relocation, known as the Gold Hill line, 9¾ miles long, was formally turned over to the Panama R.R. Co., May 25, and the relocation organization, which has been conducted as an independent department, ceased to exist, June 30, the close of the fiscal year. The large cuts and fills on the new line have been practically completed, and such riprapping of fills as will be necessary, will be done by the maintenance-of-way forces.

The relocated line of the Panama R.R. was made necessary by the building of an 85-ft. level lock canal. The old Panama R.R. was used from Colon to Mindi, 5 miles, but from that point to Corozal, an entirely new line had to be constructed, for the most part through difficult territory. Surveys were made in 1906, but it was not until June, 1907, that actual construction work was begun.

The lock-level canal required that the new railroad be built 2 ft. above the proposed Gatun lake level, which necessitated constructing a high level roadbed through a low level country. The greater part of the time and expense has been necessitated by the crossing of the Gatun valley. From the point where the road leaves the Gatun ridge, to the hills near Monte Lirio, a distance of 3½ miles, the line crosses the main valley of the Gatun River and its several tributaries. In this section there has been placed 5,500,000 cu.yd. of embankment. The foundation for some of these embankments was very poor, which necessitated spreading the base of the embankment over a much wider section, in order to reduce the pressure per sq.ft. and prevent upheaval of the normal surface beyond the toes of the slope.

The old line crossed the Chagres River at Barbacoas. The new line crosses it at Gamboa, 10 miles further upstream. The Gamboa bridge is 1320 ft. long, and consists of fourteen 80-ft. through girder spans, and one 200-ft. through truss span. The only other bridge of size along the route will be that over the Gatun River, near Monte Lirio. It is of the bascule, or balanced lift type.

The original plan was to have the relocated line cross the Gatun River valley, at Gatun, on an embankment 82 ft. high and 1¼ miles long. Borings established that the foundation for this embankment would consist of a 20-ft. stratum of clay overlying a bed of soft silt, and the plan was abandoned. The construction of a steel viaduct to cross this section was then considered, but on account of the excessive maintenance cost involved, this plan was also given up. In July, 1907, the plan of extending the road east along the north side of the Gatun River valley to a point about one mile from the Canal Zone boundary line, thence building it south across the valleys of the Quebrancha and Gatun rivers on fills having more stable foundations was adopted.

The total length of the new road from Colon station to Panama station is 47.11 miles against 47.7 miles for the old line. The total cost will be about $9,000,000.

Water Pollution Control in Ohio

The authority of the state board of health of Ohio to compel the cities and villages of that state to establish sewage purification plants on finding that water pollution constituting a public nuisance detrimental to health is being created has been affirmed by the supreme court of that state. The court decision was rendered on a demurrer filed by the state board of health in an injunction suit brought by the city of Greenville to restrain the board from enforcing the law. The greater part of the opinion of the court, which was unanimous, is here given.

The power of the Ohio state board of health to compel municipalities to build sewage-purification works has been established by a recent decision of the supreme court of that state.* We are indebted to James E. Bauman, secretary of the board, for a copy of the decision.

Greenville built a separate system of sewers in 1890. Its sewage discharges into Greenville Creek, a stream represented as having a drainage area of 140 sq.mi. The outlet is beyond the city limits, "in the open country," 10 miles above any city, town or village located on the creek.

Acting upon a complaint from the trustees of the township of Greenville to the effect that the discharge of the sewage of the city constituted a nuisance, the state board of health made an investigation and on Sept. 23, 1908, gave a hearing as required by law. At the hearing the city named was given an opportunity to show cause why it should not be ordered to build sewage-purification works by Oct. 1, 1909. On the same day the board ordered the city "to purify its sewage in a manner satisfactory to the board" by the date just named, and on Jan. 4, 1909, the order was approved by the governor and the attorney general of Ohio.

The city having taken no steps to carry out the order of the board up to Oct. 31, 1909, the board on that date notified the city that it must proceed to carry out the order or else it would be prosecuted under the law. Subsequently, the city took steps to build purification works, but it also sought an injunction restraining the board from enforcing its order. The city alleged, in the course of the various proceedings, that it would cost $35,000 to construct and $3000 a year to operate and maintain the plant in question; that its population was 8000, its bonded and other indebtedness $324,246; its assessed valuation $4,068,700, and its current tax levy 33 mills; that if forced to borrow money for sewage-purification works, other improvements, important and necessary, must be deferred; that the discharge of untreated sewage into the creek did not create a public nuisance detrimental to health or comfort, but that the proposed works would do so; that the order was unreasonable, and not based on findings of fact, and that the act on which the order was based was unconstitutional.

In the slow course of legal action, the city, on May 20, 1910, filed an amended petition, based on a motion of the state board of health that the city should comply with certain formalities in the line of greater definiteness of its causes for action. After this, the board filed a demurrer, which was sustained by the court of common pleas, overruled by the circuit court, and finally, early in the present year (1912), sustained by the state supreme court.

By mutual consent, the only question before the supreme court was the constitutionality of the act of 1908. This was upheld on every point raised. The court also took occasion to point out that the questions of "abuse of discretion" and "insufficiency of findings" by the state board of health, also raised in the demurrer, could not properly be considered by the court, since the city had not exhausted the remedies provided by the act for protecting itself when it deemed protection necessary—namely, an appeal to an engineer commission, or a virtual board of arbitration.

The city maintained that the act in question is unconstitutional because:

(1) It provides for compulsory arbitration, and therefore in conflict with Sec. 5 and 16 of Art. 1 of the constitution of the State of Ohio.

(2) It coerces city officials into compliance with the orders of the state board of health, and controls their discretion by severity of penalty, and, therefore, in conflict with Sec. 1 of Art. 14 of the constitution of the United States.

(3) It delegates the taxing power of said city to the state board of health, and, therefore, in conflict with Sec. 2 and 5 of Art. 12 of the constitution of the State of Ohio.

(4) Said act being a law of a general nature does not have uniform operation throughout the state and is, therefore, in conflict with Sec. 26 of Art. 2 of the constitution of the State of Ohio. [This contention referred to the exemption of cities and villages on the Ohio River from the provisions of the act so long as the unpurified sewage of cities or villages in other states is discharged into the river above said Ohio municipalities.]

After stating that doubt as to the constitutionality of a statute is to be construed in favor of the statute in lieu of clear proof of unconstitutionality, and after showing by citation that the general provisions of the act fall unquestionably within the police power of the state, the decision takes up the several contentions cited just above. The larger part of the opinion, which was written by Judge Donahue and concurred in by Chief Justice Davis and Judges Spear, Shauck and Johnson, is as follows:

(1) The first contention of counsel for defendant in error is that it provides for compulsory arbitration, and is, therefore, in conflict with Sec. 5 and 16 of Art. 1 of the constitution of the State of Ohio. Sec. 5 of Art. 1 provides that "The right of trial by jury shall be inviolate." Sec. 16 provides that "All courts shall be open, and every person, for an injury done him in his land, goods, person, or reputation, shall have remedy by due course of law; and justice administered without denial or delay." If this objection were sustained it would by no means invalidate the whole statute, but, in so far as this defendant in error is concerned, there is in this provision no violation of its constitutional rights. The powers of a municipal corporation are delegated powers. It is a creation of statute over which the general assembly of Ohio has as sovereign control as it has over any other part of the territory embraced within the state limits, and the municipal legislature has such power only as the legislature of the state sees fit to confer upon it, and it may grant or withhold at pleasure. A municipality is at best but a mere agency of the state, and its right to control its own local affairs rests wholly on the general grant of powers by the general assembly of the state. The state is still the sovereign and may extend, limit or revoke these powers at will. In granting to a municipality certain powers to be exercised for the benefit of the public health of that municipality the state has not relinquished its authority and control in this important particular over any of the territory comprised within the limits of the state. The duties and powers of the state board of health extend throughout the state irrespective of political divisions or territories embraced within municipalities. Sec. 1237, General Code, provides that:

> The state board of health shall have supervision of all matters relating to the preservation of life and health of the people and have supreme authority in matters of quarantine, which it may declare and enforce, when none exists, and modify, relax or abolish, when it has been established. It may make special or standing orders or regulations for preventing the spread of contagious or infectious diseases, for governing the receipt and conveyance of remains of deceased persons, and for such other sanitary matters as it deems best to control by a general rule.

Sec. 1238 provides that:

> Local boards of health, health authorities and officials, officers of state institutions, police officers, sheriffs, constables and other officers and employees of the state or any county, city or town-

*The legislation underlying this case, known as the Bense Act, was passed by the legislature early in 1908, and is now Sec. 1249 et seq. of the General Code of Ohio. The original act was printed in full on p. 396 of our issue of April 9, 1908. Editorial comment appeared on p. 400 of the same issue.

ship, shall enforce the quarantine and sanitary rules and regulations adopted by the state board of health.

These general provisions for the preservation of the life and health of the people of this state are no more suspended in the territory comprised within a municipality than are the criminal laws of the state, and the case now under consideration would illustrate the folly of a state delegating to any municipality full and complete control of matters pertaining to the public health. A municipality might then in the preservation of sanitary conditions in its own territory work incalculable mischief to the health and comfort of people living in adjacent territory. To prevent this being done, it is primarily necessary that there should be one central authority clothed with the power of affording equal protection to all. The provision in this legislation by which a municipality may challenge the judgment of a state board of health and submit the question to a board of arbitration composed of men skilled in sanitary work is a most liberal provision so far as municipalities are concerned, and far more liberal than many of the statutes relating to the powers of a state board of health. There is no theory upon which a mere agency of the state has a right to litigate the right of the state to enforce through any agency it pleases sanitary rules and regulations for the preservation of the health and comfort of all the people of the state.

(2) The second ground urged against the constitutionality of this act is that it coerces city officials in the compliance with the orders of the state board of health and controls their discretion by severity of penalty, and is, therefore, in conflict with Sec. 1, Art. 14, of the constitution of the United States which provides: "No state shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any state deprive any person of life, liberty or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws."

What has been said with reference to the first objection to the constitutionality of this legislation, as well as what further may be said with reference to the third objection, applies equally to this contention. The state does not seek to control the discretion of the municipal authorities in this matter, but on the contrary refuses to commit to them any discretion touching the particular matters committed to the care and control of the state board of health. In so far as they are charged with any duty in reference to the carrying out of the orders and directions of the state board of health they are ministerial officers only, and it is fully settled that a public officer may be required to perform a ministerial act and that a failure or refusal by such officer to perform a ministerial act may be made a criminal offense and punished as a misdemeanor. The question whether he is guilty of this misdemeanor is a proper question for judicial inquiry, and, if he be innocent of any dereliction, neglect, or refusal on his part, the courts will protect him. The law in this respect does not seek to deprive him of liberty or property within due process of law, nor does it deny to him equal protection of the laws. In our system of government there is nothing anomalous in the fact that an officer that is vested with official discretion in many matters and things pertaining to his office may nevertheless be required to perform certain ministerial duties. In so far as official discretion is concerned, courts will not interfere unless he is guilty of a plain abuse of discretion, but ministerial acts may always be enforced and there is no constitutional objection to imposing upon him, for failure to perform ministerial duties, a fixed penalty or a penalty within fixed limits to be imposed by the tribunal authorized to determine his guilt or innocence.

(3) Far more difficult is the question of the right of the legislature to compel the local taxing power to act in a ministerial capacity. If it has this right then nothing further need be said touching the second ground urged by the defendant in error, for if in this respect the municipal authorities are lawfully and properly shorn of discretion and are performing merely a ministerial duty in levying the taxes necessary to comply with the order of the state board of health then the provision for penalties for failure to do this is clearly constitutional, and this brings us to the consideration of the third contention, that the legislation is unconstitutional because it delegates the taxing power of the city to the state board of health, and for this reason is in conflict with Secs. 2 and 5 of Art. XII of the constitution of the State of Ohio. Sec. 2 provides for taxing, by a uniform rule, of moneys, credits, investments in bonds, stocks, joint stock companies or otherwise; and also of real and personal property according to its true value in money, except as to certain bonds, burying grounds, school houses, churches and institutions of purely public charity and property used exclusively for any public purpose, and certain exemptions for each individual. Clearly this law is not in conflict with this provision of the constitution, for all property within the city is to be equally taxed and the only question that could arise is as to whether the improvement ordered is particularly required by the people of the city, and is so exclusively for their benefit that the city alone should bear the entire cost. About this question there can be but little doubt. If the city possessed the absolute right to discharge its sewage into a living stream of water, thereby polluting the same and destroying all riparian rights below and creating a menace to the health and comfort of those living on the banks of this stream below the point of discharge, then it might be said that any change in the manner of sewage disposal would not be for the benefit of the city, but for those citizens of the state residing below the outlet of the city sewers. But the city has no such absolute right, and whenever this condition of affairs exists it is right and proper for the state to interfere and to prevent it from a further continuance of this nuisance, and the city then having no other means for the disposal of its sewage, it is primarily for its benefit that such disposal plant must be established. While it then becomes largely a local improvement, yet it is not one that the state has delegated to the municipal authorities complete and absolute control thereof. The health of the inhabitants of the city is still a matter of concern to the state, and of such vital concern that the general assembly has not thought proper to commit it exclusively to the control and discretion of men who may not have any particular ability or experience in sanitary affairs. *The loss of a single life is a direct economic loss to the state, and, therefore, it wisely refrains from committing to inexperienced people final discretion as to the means and methods of preserving the life and health of its citizens* [italics ours—Ed.], but aside from the concern of the state for the health and comfort of the residents of any one city, its vigilance seeks to serve a larger purpose.

Cities are no longer inclosed by stone walls and separate and apart from the balance of the state. The sanitary condition existing in any one city of the state is of vast importance to all the people of the state, for if one city is permitted to maintain unsanitary conditions that will breed contagious and infectious diseases, its business and social relation with all other parts of the state will necessarily expose other citizens to the same diseases. But with the wisdom or folly of withholding from the coal authorities final discretion over these matters, we are not concerned. It is beyond question the right of the general assembly to do so, and the court need not, and ought not to inquire what motives moved it in withholding such power.

The disposal plant is for the benefit of the residents of the city. It is the primary duty of the city to provide for sanitary disposal of its sewage, and it is not in violation of any provision of the constitution that it should bear the entire cost of erecting and maintaining a purification plant, and to require it to do so is not an arbitrary, unreasonable or unfair exercise of the police power of the state. *State ex rel v. Freeman*, 61 Kan., 90; *State ex rel Bulkley v. Williams*, 68 Conn., 131.

Sec. 5 of Art. XII provides that no tax shall be levied except in pursuance of

law and every law imposing a tax shall state distinctly the object of the same to which only it shall be applied. It is difficult to see how this legislation offends against this provision of the constitution. * * *

This law does not pretend to clothe the state board of health with the power to levy taxes, but it does confer on that board the power to determine, subject to the right of appeal to a board of arbitrators, as therein provided, the right to require the city to install works or means satisfactory to the board for purifying, or otherwise disposing of its sewage, and leaves to the municipal authorities the duty of complying with this order and of providing by taxation the means with which to comply therewith. This legislation does not differ in any particular with many other provisions relating to the power of the state board of health. We must not overlook the fact that the general assembly is sovereign. It creates this state board of health as an agency to assist it in that important function of government looking to the preservation of public health and comfort, and authorizes it to determine what will best conduce to such ends, and then it directs other agencies of the government to carry into effect the orders and directions of that board. It could do all this without the aid of any agency. The fact that a principal employs an agent in the conduct of his business in no way curtails the power and authority of the principal. * * *

In this case it is apparent that the tax is levied for governmental purposes clearly within the powers of the general assembly, notwithstanding it is especially for the needs and the benefits of the city of Greenville and is primarily for the corporate purposes of the city of Greenville. This fully appearing, it is not arbitrary or unfair to require the city to bear the burden and to conform to the orders and requirements of the state board of health by discontinuing the discharge of its sewage into a living stream and providing a proper disposal plant, so that the health of not only the citizens of the state residing in that city shall be preserved and protected, but of all the people in the state coming in business or social relation with them. The state would be powerless to perform this important function of government if the local officers were permitted to exercise their discretion in levying or refusing to levy a tax for that purpose.

(4) The fourth objection to this act of the general assembly, urged by counsel for plaintiff in error, in their printed briefs is as follows: "Said act being of a general nature, does not have uniform operation throughout the state, and is, therefore, in conflict with Sec. 26 of Art. 2 of the constitution of the state of Ohio." That portion of the act said to violate this provision of the constitution is as follows:

> Provided that no city or village that is now discharging sewage into any river which separates the state of Ohio from another state shall be required to install sewage purification works as long as the unpurified sewage of cities or villages in any other state is discharged into said river above said Ohio city or village.

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In the General Code of Ohio, the language of this section has been changed and it now reads: "But no city or village discharging sewage into a river which separates the State of Ohio from another state," etc. Therefore, the statute as it now reads exempts all cities that may now, or hereafter, discharge sewage into a river which separates the State of Ohio from another state so long as the unpurified sewage of cities or villages of another state is discharged into the river above such village or city of this state and we take it that counsel is more particularly interested in having the constitutionality of the present law determined than in having this court answer a moot question.

The question then presented is whether the general assembly of Ohio has attempted a classification or an exception which is a false, unnecessary and arbitrary one, or whether it be reasonable, just and necessary. This court has repeatedly held that classification is often proper and sometimes necessary in legislation in order to define the objects on which the general law is to take effect, but has taken equally as firm a stand against any arbitrary, vicious or faulty classification used to evade this constitutional limitation. *Gentsch* v. *State*, 71 Ohio St., 151. We take judicial notice of the fact that the Ohio River is the only river that comes within the terms of this exception. This river separates the State of Ohio from the States of Kentucky, West Virginia and Pennsylvania. * * *

It has been repeatedly held by this court that where a law is available in every part of the state as to all persons and things in the same condition or category, it is of uniform operation throughout the state. *State v. Spellmire*, 67 Ohio St., 77; *Cincinnati* v. *Steinkamp*, 54 Ohio St., 284; *McGill* v. *State*, 34 Ohio St., 228; *State* v. *Bargus*, 53 Ohio St., 94.

This law does operate uniformly in every part of the state upon all persons and things in the same condition or category. There is a substantial reason for excluding from the operation of this statute those persons, corporations, villages and cities located on the banks of a stream that separates Ohio from another state. It is not an attempt by the general assembly of Ohio to avoid the limitation of this provision of the constitution by a false or faulty classification, but on the contrary is a fair and honest effort to legislate for all the people of the state without unjust or arbitrary discrimination in favor of one class to the advantage of another. To compel those persons, corporations, villages and cities bordering upon the Ohio River to refrain from discharging sewage into the Ohio River, while the cities on the opposite banks are so doing would serve no purpose and accomplish no good results. It would be an absurdity to impose useless burdens upon them, and the purposes of the statute would be no nearer accomplished than by excluding them from the operation of the law, and would be so unjust and arbitrary as to shock the public conscience. The fact that it would be productive of no good results is sufficient reason for the classification, and for exempting them from the provisions of this law.

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The only other question in the record is the one arising upon the demurrer to the third cause of action [not cited here in specific terms—ED.]. Counsel have not discussed this question in either of the printed briefs filed in this cause, yet it is referred to in the brief filed by the defendant in error. In this third cause of action the further question is sought to be raised as to abuse of discretion on the part of the state board of health, and as to the insufficiency of its findings to warrant the orders made. * * * There is, however, no averment in this cause of action, nor in any part of the petition, that the city authorities have availed themselves of the remedy by appeal provided by the statute itself, and, therefore, it is apparent that the city has not exhausted its legal remedy, and at this point in the proceedings a court of equity would not be justified in interfering. Really the sole question in this record is the question of the constitutionality of this act, for if this act is constitutional it is evident that so long as it affords a further remedy, of which the plaintiff below has not availed itself, then a court of equity must deny relief until all legal remedies are exhausted, and will not inquire whether a board or officer clothed with discretion in determining the matter at issue has abused this discretion or exercised it fraudulently and corruptly, for a resort to the remedy provided by the statute might make such inquiry entirely unnecessary and useless.

The judgment of the circuit court is reversed for error in overruling the defendant's demurrer to the amended petition and this cause is remanded to the circuit court of Darke County with directions to sustain this demurrer.

Advantage of Technical Education—Let us accept, as a "parable," two young men of equal age and equal abilities, one technically educated, the other a "scientific illiterate." Which of the two will the better grasp the higher lines of the profession? If one should assert that the untrained youth will do better, or as well as the other, such a person will class himself with the fireman who asserted that he could raise steam quicker from cold than from hot water.—Regis Chauvenet, in "Mines and Minerals."

Locomotive Developments of 1911

Every year marks some lines of development in locomotive design, and we undertook recently an inquiry as to important or significant features of development followed by certain leading railways during 1911. The compilation of the material thus secured has been delayed somewhat, but the information relative to individual roads is presented herewith as matter of interest and record, and in our editorial columns we have discussed some of the general features which are significant of present and prospective development.

Baltimore & Ohio R.R.

This road introduced in 1911 four types of locomotives which it had not used previously, as follows: 4:6:2, passenger (40); 2:8:2, freight (160); 0:8:8:0 Mallet, pusher (20); 2:6:0 switching (10). These aggregated 230 in number. Their leading dimensions are given in Table I, and the freight and switching engines are shown in Figs. 1 and 2. None of these engines involved any new features in boiler design, but in each case the boilers were larger than those used previously. All the locomotives (except the switching engines) have the Walschaerts valve gear, but this is not a new departure, as it had been used generally for a year or two. Superheaters of the Schmidt type were applied to all the Mallet engines, 20 of the 2:8:2 engines and 30 of the 4:6:2 engines. No feed-water heaters were used. An unusual feature of the switching engines is the use of a leading truck. These engines are used in heavy yard switching and the truck was adopted in order to reduce the damage done to the track by ordinary switching engines.

The Mallet engines present some points of special interest. With their enormous fireboxes (10½x9½ ft. at the grate) it would be difficult to maintain efficient firing by hand in regular road service, but as the engines are used mainly as helpers no trouble is experienced. However, one of the engines is equipped with the Crawford automatic stoker (Engineering News, Apr. 13, 1911), as a matter of experiment. Another feature is the great diameter of the low-pressure cylinders, 41 in.; in other large Mallet engines the diameter rarely exceeds 38 in. The cylinders are 89 in. between centers and the outside width over cylinders is 11 ft. 4 in., which comes very close to the clearance limits, and on some curves the tracks have been spread to avoid possible interference. Otherwise there is no trouble on this road, but some trouble was experienced in finding a route by which the engines could be sent from the builder's plant to the B. & O. R.R. on account of clearance conditions. On these engines, also, the minimum driving axle load is 55,600 lb., while for the front main drivers the load reaches a maximum of 61,600 lb. On the 15-ft. wheelbase of each group of eight driving wheels there is concentrated a load of about 115 tons.

Boston & Maine R.R.

During 1911, there were 100 new locomotives added to the equipment, all being heavier than previous engines of the same types. These comprised 40 passenger 4:6:2 (Pacific), 40 freight 2:8:0 (consolidation) and 20 six-wheel switching engines. On several divisions the tracks have been relaid with heavier rails, several new bridges have been installed, and old bridges strengthened to permit of the use of the heavier road engines. All the boilers have Tate flexible staybolts, and are equipped with the Talmage washout ashpan system. In this latter construction revolving doors are used on the hoppers, providing large capacity and quick and thorough cleaning facilities for the ashpans. A feature of the passenger engines is the adjustment of lead in the Walschaert valve gear so as to give a variation favorable to forward motion at the expense of the backing motion. The lead obtained is ⅛ in. full gear forward motion, 3/32 in. running cutoff, ½ in. approximately in extreme backward motion. The valves are of the inside-admission piston type with 6¾ in. travel, 1⅛ in. lap, and ¼ in. exhaust clearance. This arrangement gives a smarter or quicker acting and better running engine than the 1910 engines of the same class, which had 6 in. valve travel, ¼ in. constant lead, 1⅛ in. lap and ⅛ in. exhaust clearance. The comparative features of the 1910 and 1911 engines are shown in Table II.

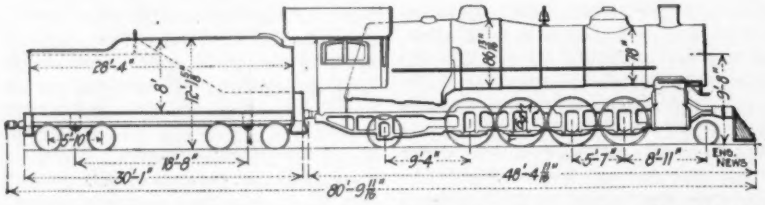


Fig. 1. Freight Locomotive of the 2:8:2 Class; Baltimore & Ohio R.R.

Chesapeake & Ohio R.R.

Two very important developments were made in 1911 for the purpose of increasing traffic capacity and economy. The Alleghany District includes a 17-mile grade of 0.57% against the heavy eastbound traffic in climbing the western slope of the Alleghany Mountains, and for several years the trains on this district have been handled by 2:8:0 (consolidation) engines having cylinders 22x28 in., 56-in. driving wheels and 41,000 lb. tractive force. These engines have now been replaced by Mallet articulated engines of the 2:6:6:2 class weighing about 200 tons and having 73,000 lb. tractive force; they have cylinders 22x32 in. and 35x32 in., and 56-in. drivers. The 25 Mallet engines do the work of 44 of the 2:8:0 engines. The Mountain District has grades of 1.5% (with 4° curves) and 1.23% (with 10° curves), and here passenger trains of eight cars have been handled by two 4:6:2 engines (cylinders 22x28 in.) to each train. Double-header working is far from economical, and these engines have now been replaced by engines of the 4:8:2 class having cylinders 29x28 in. and 62-in. drivers; one of these will make schedule time with a train of 10 to 12 cars. All the locomotives are equipped with Schmidt superheaters, and the Mallet locomotives have the feed-water heaters of the American Locomotive Co. The 4:8:2 (mountain) engines are equipped with the Street mechanical stoker, as the consumption of coal on

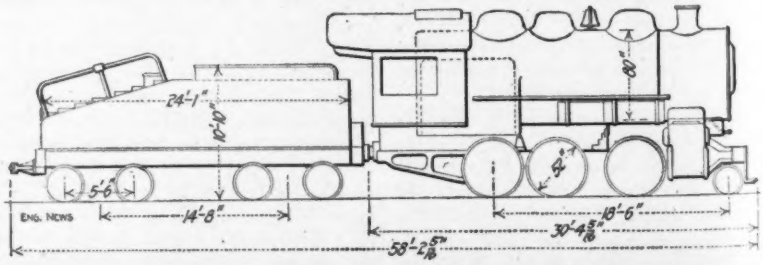


Fig. 2. Switching Locomotive of the 2:6:0 Class; Baltimore & Ohio R.R.

TABLE I. DIMENSIONS OF NEW LOCOMOTIVES OF 1911 ON THE B. & O. R. R. AND P. R. R.

	Baltimore & Ohio R. R.				Pennsylvania R. R.		
	Pass.	Freight	Pusher	Switching	Pass.	Pass.	Freight
	4:6:2	2:8:2	0:8:8:0	2:6:0	4:4:2	4:6:2	2:8:0
Wheels: driving	6 ft. 2 in.	5 ft. 4 in.	4 ft. 8 in.	4 ft. 4 in.	6 ft. 8 in.	6 ft. 8 in.	5 ft. 2 in.
Front truck	2 ft. 9 in.	2 ft. 9 in.	.....	2 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.	2 ft. 9 in.
Rear truck	3 ft. 8 in.	3 ft. 8 in.	.....	.....	4 ft. 2 in.	4 ft. 8 in.	.....
Tender	3 ft. 0 in.	2 ft. 9 in.	2 ft. 9 in.	2 ft. 9 in.	3 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.
Wheelbase: driving	13 ft. 2 in.	16 ft. 9 in.	(2)15ft.0 in.	11 ft. 0 in.	7 ft.5 in.	13 ft. 10 in.	17 ft. 0¼ in.
Engine	34 ft. 8 in.	35 ft. 0 in.	40 ft. 8 in.	18 ft. 6 in.	29 ft. 7½ in.	35 ft. 2½ in.	25 ft. 7½ in.
Tender	24 ft. 6 in.	24 ft. 6 in.	24 ft. 6 in.	20 ft. 2 in.	23 ft.8 in.	23 ft. 8 in.	20 ft. 8 in.
Engine and tender	70 ft. 8 in.	71 ft. 2 in.	77 ft. 3 in.	51 ft. 11 in.	63 ft. 8 in.	70 ft. 0 in.	59 ft. 6 in.
Weight, on driv. lb.	172,390	223,600	461,000	164,250	133,300	178,500	211,000
Max. axle load lb.	59,600	56,450	61,600	56,650	68,800	62,000	58,100
Front truck lb.	55,500	18,400	.....	12,850	51,300	47,500	27,300
Rear truck lb.	49,100	40,200	.....	.....	46,900	46,000	.....
Engine lb.	277,190	282,200	461,000	177,100	231,500	272,000	238,300
Tender lb.	192,000	181,500	181,500	140,000	158,000	158,000	143,000
Cylinders	24x32 in.	26x32 in.	41x32 in.	21x26 in.	22x26 in.	24x26 in.	24x28 in.
Boiler, diam.	6 ft. 6 in.	6 ft. 6 in.	7 ft. 6 in.	6 ft. 8 in.	6 ft. 6 in.	6 ft. 6 in.	6 ft. 6 in.
Height to center	9 ft. 11 in.	9 ft. 8 in.	10 ft. 1 in.	9 ft. 10 in.	9 ft. 8½ in.	9 ft. 11 in.	9 ft. 9 in.
Superheater, type	Schmidt	Schmidt	Schmidt	.....	.....	.....	.....
Working pressure	205 lb.	190 lb.	210 lb.	200 lb.	205 lb.	205 lb.	205 lb.
Firebox, size inside	7x10 ft.	7x10 ft.	10½x9½ ft.	5½x7 ft.	6x9½ ft.	6x9½ ft.	6x9½ ft.
Tubes, No.	218+34	218+34	277+38	400	460	359	465
Diameter	2¼+5½ in.	2¼+5½ in.	2¼+5½ in.	2 in.	2 in.	2¼ in.	2 in.
Length	20 ft. 11 in.	20 ft. 11 in.	23 ft. 10½ in.	10 ft. 11 in.	14 ft. 20 ft. 10 in.		15 ft.
Heat. sur. tub., sq.ft.	3708	3708	5205	2286	3364	4420	3652
Firebox sq.ft.	228	228	322	169	218	200	187
Total sq.ft.	3936	3936	5527	2455	3582	4620	3839
Superheat. sur., sq.ft.	998	998	1002	.....	.....	.....	.....
Grate area sq.ft.	70	70	100	38½	.....	.....	.....
Coal, tons	16	16	16	9	12½	12½	13½
Water, gal.	9500	9500	9500	7000	7000	7000	7000
Tractive power	43,400	54,587	s. 126,000 c. 105,000	37,400	.....	.....	.....

Notes.—All the engines have the Walschaerts valve gear, except that the B. & O. switching engines have the Stephenson gear. All have piston valves (14-in. on the B. & O.), except that the Mallet engine has flat slide valves for the low-pressure cylinders.

The weights given are for conditions in working order. Of the Pennsylvania R. R., the engine weight empty is 238,500 lb. for the 4:6:2, and 212,000 lb. for the 2:8:0; the tender weight empty is 64,400 lb. for the 4:4:2 and 57,500 lb. for the 2:8:0.

All fireboxes are of the wide type, mounted above the frames.

The height to top of smokestack averages about 15 ft., but in the Mallet pusher engines of the B. & O. this reaches 15 ft. 7¼ in.

these engines when working at full power is beyond the capacity of a fireman.

CHICAGO, MILWAUKEE & ST. PAUL RY.

All engines purchased during 1911 were of types already tried, including 2:8:2 freight, 4:6:2 passenger, Mallet articulated and large switching engines. The only special feature introduced has been in regard to superheating, and superheaters have been applied to many of the new engines.

DELAWARE, LACKAWANNA & WESTERN R.R.

The principal dimensions of locomotives built in 1911 and ordered for 1912 delivery are compared in Table III. Very little work was done in experimenting with details during 1911. The most notable example was the introduction, for test purposes, of a new method of setting the Walschaert valve gear in which the forward motion is favored, thus giving a variable lead without the addition or complication of parts. The result desired was to give the engine the benefit of lead at working speed, but to eliminate it at starting, when it is a handicap. This is very similar to the Boston & Maine practice noted above.

ERIE R.R.

ROAD ENGINES—By 1911, business on the Cincinnati Division had increased to such an extent that traffic had become seriously congested, rendering operation highly inefficient. To make matters worse, this part of the road had only a single track. Following a detailed investigation, it was decided to double-track this division and to replace the 2:8:0 (consolidation) locomotives, which for several years had been the road's standard freight engine, with more powerful locomotives of the 2:8:2 (mikado) type. This entire program has been carried out and the results are quite equal to the expectations. The new locomotives are hauling trains of 38% greater tonnage, and at a greater speed than was obtained with the others. They are equipped with modern appliances for economy in service, as noted below. Table IV gives a comparison of the principal features of the two classes of engines.

SWITCHING ENGINES—In order to properly handle the increased business of the road, and to replace condemned switch engines, switch-engine power had to be increased to avoid the possibility of congestion at the several division terminals. The standard switch engine since 1904 has been of the 0-6-0 type, weighing 148,540 lb., and having a tractive power of approximately 30,000 lb. At the end of 1910, there were 46 of these engines in service. During 1911, 15 more were built; 10 (built at the railway company's shops) are to be an improvement over the others. The main rod connection is changed from the second to the third axle, thereby eliminating the excessive wear on crosshead gibs which results from the shorter main rod. The Baker gear was specified for these engines on account of the impracticability of using the Stephenson valve gear with eccentrics on the second axle when the main rod is on the third, and also because of its well known advantages.

DETAILS OF CONSTRUCTION—The new 2:8:2 freight engines have the following features: 1. Superheaters and outside steam pipes. The superheaters are of the Schmidt type, of the large size, advantage being taken of the additional front-end space afforded by the use of outside steam pipes. The boiler pressure has been reduced to 170 lb.. 2. Baker valve gear. A year's experience with a 2:8:0 engine equipped with this gear proved it to be so satisfactory in its economy and maintenance cost that it was decided to apply it to all the new 2:8:2 engines, and also to 10 of the new switch engines. 3. Vanadium-steel frames. These have been used on some of the Erie R.R. 4:6:2 engines for three or four years, and their success is evident from the fact that the new freight engines are equipped with frames of this kind of steel. They are 6 in. wide and 7 in. deep over the pedestals, and it is expected that frame breakage will be minimized. 4. Brick arches of the Security type have

TABLE II. COMPARISON OF SIZE OF LOCOMOTIVES OF 1910 AND 1911; BOSTON & MAINE R. R.

	Pass., 4:6:2		Freight, 2:8:0		Switching, 0:6:0	
	1910	1911	1910	1911	1910	1911
Driving wheels	6 ft. 1 in.	6 ft. 1 in.	5 ft. 1 in.	5 ft. 1 in.	4 ft. 3 in.	4 ft. 3 in.
Weight; on drivers lb.	142,000	146,000	153,000	182,000	122,000	140,000
Engine lb.	219,000	233,000	178,000	206,000	122,000	140,000
Tender lb.	140,000	145,000	120,000	145,000	89,000	94,000
Cylinders	22x28 in.	22x28 in.	20x30 in.	22x30 in.	19 x24in.	19x26 in.
Boiler, diam. in.	70	70	66	70	64	66
Firebox in.	75½x96	71½x107½	65½x102	71½x108	32½x102	39½x102½
Tubes, No.	342	310	326	366	259	263
Diameter	2 in.	2¼ in.	2 in.	2 in.	2 in.	2 in.
Length	19 ft. 6 in.	20 ft. 6 in.	16 ft. 0 in.	15 ft. 8 in.	11 ft. 0 in.	11 ft. 6 in.
Heating surface sq.ft.	3660	3945	2860	3189	1636	1722
Grate area sq.ft.	50.2	53.2	46.5	53.4	22.8	27.8
Water in tank gal.	6800	7,400	5,600	7,300	4,000	4,500
Tractive power	31,600	31,600	33,400	40,500	23,600	31,300

TABLE III. COMPARISON OF SIZE OF LOCOMOTIVES OF 1912, 1911 AND PREVIOUS YEARS: DELAWARE, LACKAWANNA & WESTERN R. R.

	Passenger		Freight		
	1912	Previous standard	1912	1911	Previous standard
Type	4:6:2	4:6:0	2:8:2	2:8:0	2:8:0
Weight on drivers lb.	171,000	164,000	240,000	211,000	168,000
Cylinders in.	25x28	22½x26	28x30	26x30	21x26
Boiler, diam	68 in.	73 in.	36 in.	80 in.	69 in.
Working pressure lb.	200	215	180	170	200
Heating surface sq.ft.	3,808.0	3,425.0	4,885	3,728	2,789
Grate area sq.ft.	94.5	103.5	63	58	95
Tractive power lb.	40,700	34,861	57,000	51,400	34,197

been applied to the fireboxes. 5. Power reversing gear is used, not so much on account of the difficulty of reversing by hand, as because of the fact that a quadrant could not be suitably located in the cab, owing to the limited space.

Aside from the new features embodied in the freight engines and in some of the new switch engines, there are several improvements completed and others in contemplation for some of the older equipment. Brick arches have been applied to several of the standard switch engines, and they are being applied to a few of the 4:6:2 passenger engines. Tests have proved that the brick arch, properly maintained, is a source of appreciable saving over and above its maintenance cost. It is among the best known features for preventing smoke, and in cities where railways are fined for violating the smoke ordinances the brick arch is being used to a considerable extent. Superheaters of the Schmidt type are being applied to a few of the 4:6:2 locomotives, and their economy and efficiency are so marked that they are to be applied to all locomotives of this class. There being no longer any question as to the service of flexible staybolts as compared with rigid bolts, the number of flexible staybolts in the breaking zones of some fireboxes has been increased, and it is probable that more and more of these bolts will be applied in the future, particularly on new locomotives.

Vanadium steel in forgings and castings has long since proved its value, and its use for frames has already been mentioned. As some annoying failures have occurred through the breaking of main and side rods of ordinary steel on the 4:6:2 passenger engines, vanadium-steel rods are to be applied to all these engines, and it is expected that failures of this sort will be practically eliminated. Frequent failures have occurred in the past on several classes of engines due to breaking of front cylinder heads. As a result of careful investigation, some of the cylinder heads (of the design which failed most) were changed from iron to cast steel; the others were redesigned so as to have greater strength, the material remaining the same.

Illinois Central R.R.

During 1911, this road acquired 100 freight engines of the 2:8:2 (mikado) class, having cylinders 27x30 in.; they carry 175 lb. boiler pressure and have a tractive effort of 51,630 lb. These engines are assigned to freight service and will replace 2:8:0 consolidation engines having cylinders 22x30 in. and tractive effort of 39,180 lb. They are fitted with the Schmidt top-header type of superheater, and this accounts for the low steam pressure. No experiments were conducted during the year, with the exception of a comparative test between two Pacific type locomotives, one furnished with a superheater and the other operating under saturated steam.

Louisville & Nashville R.R.

No new types of locomotives were introduced during 1911, but the road (which builds nearly all its own engines) built 33 engines of the 2:8:0 (consolidation) class having an increase of 30,000 lb. in weight (in working order) and 7500 lb. in tractive power as compared with the heaviest type of freight engine in service prior to July 1, 1911. Eight of these new engines were equipped with superheaters. Preliminary comparative tests of the superheater engines with the engines of the same type using saturated steam, show a very gratifying increase in the tonnage handled and a decrease in the consumption of water and fuel. The road is now building five 4:6:2 passenger engines, weighing 16,000 lb. in excess of the engines of the same type previously in service, and having an increase of 3000 lb. in tractive power. These engines also will be equipped with superheaters.

Norfolk & Western R.R.

The standard freight engine is of the 2:8:0 class, and the design used up to September, 1910, had a tractive power of 40,000 lb. At that time the engine was redesigned, increasing the tractive power to about 50,000 lb.; since then about 55 of the more powerful engines have been acquired. In May, 1910, however, the road procured ten Mallet engines of 85,000 lb. tractive power for pusher service. It has now added 15 Mallet engines of the 2:6:6:2 type, having 372,900 lb. on the drivers. As to details of locomotive design and equipment this road has not taken up any new types of boilers or fireboxes, but it has taken up quite extensively the Baker-Pilliod valve gear, having applied it to all of the recently built large passenger engines. It is now considering the value of superheating, and the new Mallet engines are to be equipped with superheaters.

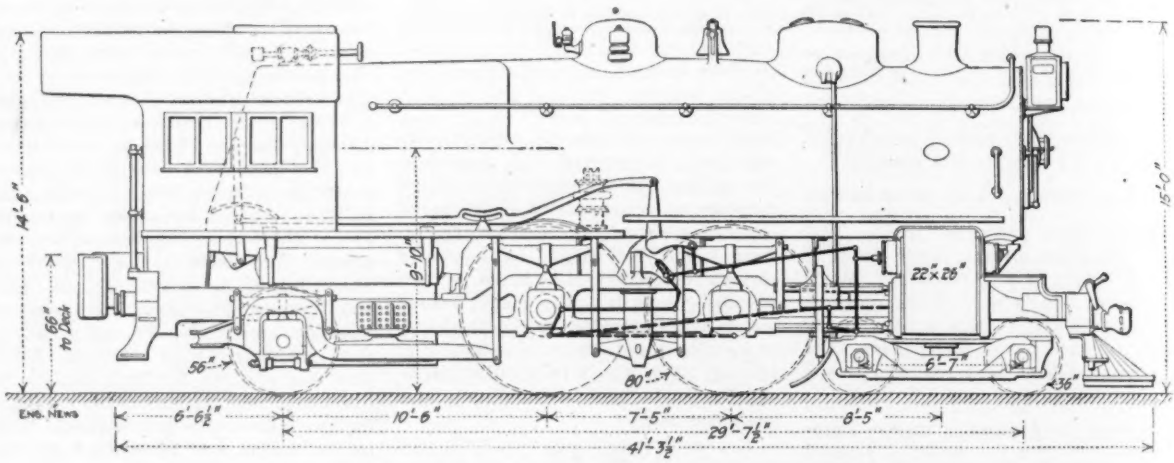


Fig. 3. Heavy Passenger Engine of the 4:4:2 Class; Pennsylvania R.R.

Pennsylvania Lines

No locomotives of new type were introduced during 1911, but experiments were made with the application of superheaters to the standard 4:6:2 passenger engines and heavy freight engines of the 2:8:0 class. There are now 27 superheater locomotives in service or under construction. A more novel feature is the extensive application of mechanical stokers, and there are now 30 passenger and 40 freight engines (built or under construction) which are equipped with the Crawford underfeed mechanical stoker.

Pennsylvania R.R.

In regard to engines of new types or increased power, a very heavy passenger engine of the 4:4:2 class was designed and an experimental locomotive built.

This locomotive (known as class E-6) has made some very good records and is considered to represent the limit of weight and power which can be obtained from a simple 4:4:2 (Atlantic) type locomotive not equipped with superheater. In addition to this, a large number of 4:6:2 (Pacific) locomotives (class K-2) were built and placed in service for hauling the heaviest passenger trains. For freight service, this road continued building during 1911 its standard 2:8:0 freight locomotive, which has been found very satisfactory for fast-freight service. The latest development in switching locomotives is found in the new 0:6:0 engines (class B-6-A), ten of which have been built and placed in service at the Washington Terminal. The dimensions of the three types of road engines are given in Table I, and the heavy 4:4:2 passenger engine is shown in Fig. 3.

In details of locomotive design, as far as boilers are concerned, perhaps the most interesting features are in the boiler of the new 4:4:2 locomotives (class E-6), the combustion-chamber flanging being unique. Practically all of the locomotives built during the year were fitted with Walschaerts valve gear, and a number of the road engines were fitted with superheaters of the Locomotive Superheater Co.'s design, while a large number of locomotives have been fitted with the American Arch Co.'s fire-brick arch. The question of feed-water heaters for locomotives has received little or no attention by the Pennsylvania R.R.

St. Louis & San Francisco R.R.

During the latter part of 1910, this road put in service seven Mallet engines which were used in 1911. The object in introducing these locomotives was to determine whether it would be possible to compensate for severe grade conditions on several divisions by using Mallet engines at less expense than and with the same results as by reducing grades. These engines are of the 2:8:8:2 class; weight on drivers, 365,000 lb.; total weight of engine, 428,000 lb., tractive effort, 83,500 lb. working compound or 100,000 lb. simple. These engines can handle trains of 1600 tons on a grade of 1.75%. The greatest trouble experienced with the Mallet engine is due to the fact that the freight divisions are rather long for a locomotive of this type. They were not fitted with superheaters, but later one was equipped with a Schmidt superheater and gave much better results. There were also several minor features of these locomotives that required adjustment before the best service could be obtained from them.

In 1911 there were ordered 20 locomotives of the 4:6:2 class for heavy passenger service. These weigh 261,500 lb., with 160,000 lb. on the drivers and develop a tractive effort of over 40,000 lb. They are equipped with the Schmidt superheater. They were designed for the purpose of hauling passenger trains of 10 to 12 steel cars (averaging 70 tons per car) over a grade of 1.75%. For yard work, in 1911 there were received 12 six-wheel switch engines, weighing 154,500 lb. and developing a tractive effort of 33,700 lb. These have been placed in service in the large yards, but they are no heavier than 25 engines built for the same purpose in 1910. No experiments were made during the year with new details in boilers, fireboxes, valve gears, superheaters or feed-water heaters. The road has 70 engines equipped with superheaters, but does not regard this as experimental because from service received prior to 1911 it has become satisfied that the superheater is a paying investment.

TABLE IV. COMPARISON OF FREIGHT ENGINES OF THE NEW 2:8:2 CLASS AND OLD 2:8:0 CLASS; ERIE R. R.
(Cincinnati Division)

	New, 2:8:2	Old, 2:8:0
Driving wheels	63 in.	62 in.
Journals, main driving	11x14 in.	9½x12 in.
Other driving	11x14 in.	9x12 in.
Weight on drivers, lb.	237,150	176,400
Engine, lb.	320,600	200,700
Cylinders	28x32 in.	22x32 in.
Valve gear	Baker-Pilliod	Stephenson
Valves	Piston	Slide
Working pressure	170 lb.	200 lb.
Superheater	Schmidt	(None)
Tubes, No. and diam.	232–2¼ in.	380–2 in.
Superheat. tubes	36–5½ in.	.....
Heating surface, sq.ft.	4,155	3,339.7
Grate area, sq.ft.	70	54.0
Tractive effort	57,460	39,969

TABLE V. NEW LOCOMOTIVES OF 1911; SOUTHERN PACIFIC RY.
(The fuel is California crude petroleum)

Type	4:4:0	2:8:2	2:6:6:2 Mallet
Service	Passenger	Freight	Passenger
Driving wheels	73 in.	57 in.	63 in.
Weight, on drivers, lb.	100,000	205,000	320,100
Weight, total engine, lb.	146,000	264,800	384,800
Cylinders	20x26 in.	23½x30 in.	25&38x28
Pressure, lb.	200	180	200
Firebox, in.	108x37½	120½x84	120½x84
Tubes, No. and diam.	330–2 in.	495–2 in.	495–2 in.
Tubes, length	12 ft. 8 in	20 ft. 6 in.	20 ft. 6 in.
Feed-water heater, tubes	.....	.....	424–2¼ in.
F-w. heat. tubes	.....	.....	6 ft. 3 in.
Heating surface, tubes, sq.ft.	2,189	5,292	5,292
Heating surface, feed-water heater tubes, sq.ft.	.....	.....	1,590
Heating surface, firebox, sq.ft.	166	235	235
Tractive effort, lb.	21,220	45,420	74,074

Southern Pacific Ry.

During 1911, three types of locomotives were introduced which are noticeable for their high power: 1, a 4-4-0 class for fast passenger service on the valley lines; 2, a 2:8:2 class for heavy freight service, of greater boiler capacity and 2120 lb. greater tractive effort than former engines of the 2:8:0 class which have been found insufficient in power; 3, Mallet engines of the 2:6:6:2 class for passenger service on the Sierra Nevada division, where the ruling grade is 2.2%. One Mallet engine replaces two of the 2:6:0 engines used formerly. For convenience in operation, these engines are run with the cab and firebox leading; this is easily practicable, as oil fuel is used and the oil is led by pipes along the engine to the firebox. One of these engines was illustrated in our issue of Mar. 10, 1910. The dimensions of the three classes of engine noted above are given in Table V. Feed-water heaters of the tubular type, forming an extension of the boiler proper (but with an open space between the tube sheets of the boiler and heater) are used on the Mallet engines of the 2:6:6:2 and 2:8:8:2 classes, and have been found very successful.

Federal Locomotive Boiler Inspection—"In 1905, the state of New York passed a boiler-inspection law. Shortly afterward the state of Ohio did likewise. Then Pennsylvania started the inspection of boilers under the police powers of the state. Then the Dominion of Canada passed a law very similar to the New York and Ohio laws, and other states were preparing to pass laws. A number of Congressmen then introduced bills and those bills were all boiled down, after long conferences, until we get the law of February, 1911.

"The law required that the railroads file within three months of the passage of the act their rules for boiler inspection. These rules were to be approved by the Interstate Commerce Commission. There are about 2200 railroads in the United States engaged in interstate commerce; 170 of those roads filed rules. If you get out rules for so many railroads and 57,000 locomotives you have to have them uniform; therefore we could not adopt the 170 rules, but the chief inspectors, coöperating with a railroad committee representing most of the roads, recommended rules which the Interstate Commerce Commission adopted on June 2, 1911.

"The law provides for a chief inspector, two assistant chief inspectors, and fifty district inspectors. The country was divided into fifty districts, and we have an inspector in charge of each district. The inspectors make as thorough inspections as they can, which are in fact check inspections on the railroads. The railroads are required to live up to the inspection rules, and our inspectors visit them frequently and see that the laws are lived up to.

"We were somewhat delayed in getting these men into the field, but up to Apr. 1, 1912, we had inspected 48,000 locomotives, and out of the 48,000 we found about 67% defective. That does not mean dangerous defects; it means violation of our rules, together with a very considerable number of dangerous defects.

"Our inspectors have the right to remove a locomotive from service when it does not comply with the rules. We have taken out of service 2209 locomotives. This does not mean that we have condemned these locomotives. We never condemn a locomotive or boiler outright; we simply issue to the road a written order to remove the locomotive from service until proper repairs are made. Sometimes these repairs can be made in a few minutes, and at other times in a day or longer." (G. P. Robinson, U. S. Asst. Chief Inspector of Locomotive Boilers, before New England Railroad Club, May 14, 1912).

U. S. Government Contract Dredging

Besides the river and harbor improvement work done by the great dredging plant owned by the U. S. Government, described in our issue of May 7, a great amount of Government dredging work is done by contract. The cost of this contract dredging is summarized in this article, which affords an interesting comparison with the work done by the Government-owned plant.

In our issue of May 9 was published an article describing the work done by the dredging plant owned by the U. S. Government and operated by the Engineer Department of the U. S. Army. The same contributor has compiled for us from the annual report of the Chief of Engineers for 1911, the following information relative to the dredging done by contractors for the U. S. Government under the supervision of the Army engineers:

The accompanying Table I gives some details of this work on contracts in excess of 20,000 cu.yd. For the purpose of administration the engineering works in charge of the office of the Chief of Engineers are arranged in nine divisions, each in charge of an officer of the Corps of Engineers. Seven of these divisions are east and two west of the Rocky Mountains. Each division is divided into districts also administered by engineer officers.

The Northeast division comprises the harbors along the Atlantic Coast between Maine and New York. In the Portland, Me., district the lowest dredging price was 8.34c. per cu.yd., scow measurement.

At Boston, Mass., the main work is the dredging of the 35-ft. channel from the Charles River and Chelsea bridges to President Roads, and from there through Broad Sound to the ocean, the former section to be ultimately 1200 ft. wide and 35 ft. deep and the latter section 1500 ft. wide, with the same depth. To June 30, 1911, under various contracts, 15,988,926 cu.yd. of mud, sand, gravel and clay have been dredged in the upper main ship channel and in Broad Sound channel, 4,620,907 cu.yd. of mud, sand, gravel, clay, hard pan and cobble stones, the total amount being 20,609,833 cu.yd., scow measurement. The contract prices are 20, 22, 23.4, 23.5, 23.9c. for the inner and 39, 39.7 and 40c. for the outer channel.

Other extensive contracts are at Providence, R. I., where the price has been 7.84c.; Newport, R. I., 20c.; New Haven, Conn., 7.6c., and Bridgeport, Conn., 8⅓, 12½ and 11c. per cu.yd., scow measurement, the material being classed as mud.

In the improvement of the East River and Hell Gate, N. Y., the dredging is paid for by "clearing areas of all obstructions to a depth of 26 ft. below mean low water." The price paid is 29½c. per sq.ft. of area. A large proportion of the bed of the East River is rock of irregular formation, which at points is in pinnacles of a height of 15 to 20 ft. and with top areas of but a few square feet, which are generally missed when soundings are made by sounding line. This has necessitated the sweeping of all areas surveyed, an expensive and tedious process in a channel congested with traffic and traversed by swift currents.

The Eastern division comprises the harbors along the Atlantic Coast, New York, New Jersey, Delaware, Maryland and Virginia. One of the large contracts is the dredging of Bay Ridge and Red Hook Channels in Gowanus Bay, Brooklyn. This provides for the dredging of about 2,400,000 cu.yd. of material at 15.89c. per cu.yd. to make these channels 40 ft. deep, with such lengths and widths as the funds authorized will permit. Under the project of 1899, $2,050,644 have been expended in dredging 16,519,622 cu.yd. of sand and mud, at an average cost of nearly 12½c. per cu.yd.

Another large contract is the improvement of the Passaic River, which provides for the removal of 4,177,110 cu.yd. of material, mud, sand and gravel, scow measurement, at 16¼c. per cu.yd. The excavated material was dumped mostly along the west side of the Hackensack River, whence it was pumped ashore for land reclamation.

The next largest contract was the dredging of the Arthur Kill, or Staten Island Sound, a waterway about 12 miles long. This contract was completed Aug. 27, 1910, and 3,535,000 cu.yd. of material were excavated, at a contract price of 14.8c. per cu.yd., scow measurement. On this same improvement 13,991 cu.yd., scow measurement, of material consisting of rock, hard pan and gravel were removed. The contract price was $3.25 per cu.yd.

In the Delaware River, between Philadelphia and Trenton, under a contract with the Atlantic, Gulf & Pacific Co., of New York, 1,000,000 cu.yd. are to be dredged. The rates per cu.yd. place measurement are: Kinkora section, 12c.; Bordentown section, 15.5c.; Duck Island section, 24c.; Biles Island section, 29c.

Below Philadelphia, a contract is in force with the American Dredging Co., of Philadelphia, for dredging approximately 3,600,000 cu.yd., scow measurement, at the following places and rates: Upper and Lower Horse Shoe ranges, 13.3c.; Lower Horse Shoe and Miffin ranges, 15c.; Tinicum and Upper Schooner Ledge ranges, 18c.; Deep Water and New Castle ranges, 12c.; New Castle and Reedy Island ranges, 12½c.

The U. S. government sea-going dredges "Delaware" and "Manhattan" were engaged in maintenance dredging throughout the year at various localities in the Delaware River from Philadelphia Harbor to Delaware Bay. The reported cost per cu.yd. dredged is 1.92 and 1.73c. (see ENG. NEWS, May 9, 1912).

The Wilmington, Del., district comprises a number of small streams and harbors in New Jersey and Delaware. The deepest dredging is in Wilmington Harbor, which is 18 ft.; at other places it is from 6 to 9 ft. It generally consists in making cut-offs in small rivers emptying into Delaware Bay, some in New Jersey, and others in Delaware. The new channels range from 50 to 100 ft. bottom width. The excavated material is usually mud, sand and gravel, and is placed or dumped upon adjacent banks above high-water line. In some cases it has to be rehandled twice.

The Baltimore, Md., district comprises Patapsco River and channel to Baltimore, with dredging 35 ft. deep. The remaining harbors and rivers are along the east shore of Chesapeake Bay, in Maryland, the depth of dredging ranging from 4 to 12 ft. At Baltimore the contract prices are 5, 9½, 9¾ and 15c. per cu.yd. At all of the other rivers and harbors, with one exception, the price is 18½c. per cu.yd.

The Washington, D. C., district comprises the Potomac, Anacostia and James Rivers, with dredging depths of 26, 22 and 18 ft., respectively, and a number of rivers and harbors along the eastern shore of Virginia, north of the James River, with dredging depths ranging from 6 to 15 ft. The contract prices for work in the Potomac River are 7.89 and 6.89c. per cu.yd., there being two contracts of 1,500,000 cu.yd. each. In the James River the price is 6c., and the quantity 1,739,000 cu.yd. Table II gives details of operations in the Washington district.

The next division is the Southeast, comprising the Atlantic Coast, from Virginia to Florida. Large contracts are in force at Norfolk, one of 8,231,895 cu.yd. at 7.3c. per cu.yd., another 1,128,849 cu.yd. at 9.4c. per cu.yd., and yet another, 1,960,000 cu.yd. at 16.89c. per cu.yd., scow measure. In one contract on the Appomattox River, in 1909, the price of rock excavation was $10 per cu.yd., place measurement.

The following are the details of the dredging in the inland waterway from Pamlico Sound to Beaufort Inlet, N. C. This work is completed, the contract price

TABLE I. CONTRACT PRICES FOR DREDGING DONE FOR THE U. S. GOVERNMENT, UNDER SUPERVISION OF THE CORPS OF ENGINEERS, U. S. A.

(Only contracts above 20,000 cu.yd. are included)
*=Date of contract. †=Date of approval of work

District and locality	Contractor	Address	Depth of dredging	Date of contract or approval	Estimated quantities, cu.yd.	Scow or place	Contract price, cu.yd.	Character of material Remarks
Portland, Me.								
Union River, Me	Philip H. Doyen	South Portland, Me	6	†July 10, 1909	46,500		0.245	Mill waste.
Stockton, Me	J. S. Packard Dredging Co.		25	†Sep. 2, 1910	270,330	Scow	0.0834	Work complete: Sep. 21, 1910–Jan. 14, 1911.
Camden, Me	John H. Gerrish		10	†April 19, 1911	45,000		0.333	$8 for bowlders.
Kennebec R. Me	Eastern Dredging Co.			†Oct. 24, 1907			0.355	Work divided into 5 groups.
" "	" "	"		"	396,000	Scow	0.415	Groups Nos. 2 and 3.
" "	" "	"	20.5	"			0.90	Also removing bowlders $8 per ton.
							0.445	
Pepperells Cove, Me	" "	"	12	†Nov. 25, 1910	330,000		0.162	Also removing bowlders $8 per cu.yd.
Boston, Mass.								
Lynn, Mass	Bay State D. Co.	Boston, Mass	15	*Oct. 26, 1910	265,000		0.214	Shoal, 4500 ft. long.
Mystic River, Mass	G. H. Breymann & Bros.	Toledo, O.	25	*July 17, 1907	120,000		0.22	Mud, sand and clay.
" "	Daly & Hannan D. Co.	Ogdensburg, N. Y.	30	*Oct. 25, 1910	250,000		0.259	
Boston, Mass	Breymann Bros.	Toledo, O.		*Feb. 25, 1903	1,875,000		0.20	This work is known as the 35 ft. channel.
" "	" " "	" "		"	570,000	Scow	0.39	The work done in fiscal year 1911 was
" "	Morris & Cummings D. Co.	New York, N. Y.		*Feb. 26, 1903	1,875,000	"	0.234	2,973,734 cu.yd. of material, and all work
" "	" " "	" "		"	570,000	"	0.40	to June 30, 1911, was 20,609,834 cu.yd.
" "	George H. Breymann	Toledo, O.	35	*Feb. 25, 1903	1,875,000	"	0.235	The material is mud, sand, gravel, clay,
" "	" " "	" "		"	570,000	"	0.39	hard pan and cobble stones.
" "	Eastern Dredging Co.	Boston, Mass.		Feb. 19, 1903	1,875,000	"	0.239	
" "	New England Dredging Co.	" "		"	570,000	"	0.397	
" "	G. H. Breymann & Bros.	Toledo, O.		July 17, 1907	9,770,000	"	0.22	
" "	" " "	" "		"	2,440,000	"	0.40	
Newport, R. I.								
Nantucket, Mass	Coastwise D. Co.	Norfolk, Va.	17	†Feb. 17, 1911	142,000	Scow	0.199	Suction dredge.
Providence R., R. I.	" "	" "	25	*Jan. 13, 1911	1,698,240		0.784	Mud, etc.; $5 for bowlders.
" "	Charles M. Cole	Fall River, Mass.	25	*May 27, 1911	70,000		0.249	" $8 "
Newport, R. I.	Daly & Hannan D. Co.	Ogdensburg, N. Y.	18	*Jan. 28, 1911	769,930		0.20	" $8 "
New London, Conn.								
Connecticut R., Conn	The Hartford & New York Transp. Co.		15	*May 5, 1910	104,909	Scow	0.11	
" "	The Hartford & New York Transp. Co.			June 3, 1911	80,000	"	0.11	
Eight Mile R., Conn	T. A. Scott Co. (Inc.)		8	Aug. 29, 1910	54,482		0.135	"Ordinary material"; $10 for bowlders.
New Haven, Conn	Taylor D. Co.		12	*Jan. 7, 1911	405,000	Scow	0.076	
Bridgeport, Conn	American D. Co.		22	*Feb. 15, 1909	1,231,521	"	0.125	8½ cents for anchorage basin.
" "	Coastwise D. Co.		22	*Sep. 28, 1910	533,399	"	0.11	
Stamford H., Conn	Maritime D. Co.		7	*Feb. 6, 1911	60,000	"	0.25	Ordinary material, mud.
5 M. R., Greenwich, Conn	John P. Randerson		8	*May 24, 1911	55,000	"	0.18	Mud.
1st New York, N. Y.								
Harlem River, N. Y.	P. Sanford Ross (Inc.)		15	*Apr. 4, 1911	154,000	"	0.298	
Hudson River, N. Y.	Michael J. Dady		12	*Feb. 3, 1911	86,705	Place	3.21	Rock and overlying material.
2nd New York, N. Y.								
Gowanus Bay, N. Y.	Coastwise D. Co.		35	*Feb. 9, 1911	2,400,000		0.1589	Mud and sand. 40 ft. channel.
Flushing Bay, N. Y.	R. G. Packard Co.		6	*June 5, 1911	54,000	Scow	0.22	$8 for bowlders
Hempstead H., N. Y.	P. Sanford Ross (Inc.)		6	*May 31, 1911	100,000	"	0.21	$8 "
Newtown Ck., N. Y.	Morris & Cummings D. Co.		14	*July 14, 1910			0.175	$1.45 and $3.25 for bowlders
Wallabout Ch., N. Y.	" " "		20	* "	46,000	Scow	0.175	$1.45 and $3.25 "
3d New York, N. Y.								
Passaic River, N. J.	Midland Land & Imp. Co.		16	*Aug. 12, 1907	4,177,110	"	0.1625	Mud, sand and gravel
" "	The International Con. Co.			*May 13, 1910	39,000	"	0.50	" "
Arthur Kill, N. Y.	William H. Taylor		21	*Oct. 14, 1903	3,535,000	"	0.148	Mud, sand, gravel and clay.
Staten I. Channel	Columbia D. Co.		14	*Oct. 15, 1910	66,666	"	0.135	Mud and sand
Shooters I. Channel	William Beard & Co.		12	*Nov. 9, 1910	979,000	"	0.15½	Mud, clay, sand and gravel
Raritan Bay, N. J.	R. G. Packard Co.		21	*Nov. 3, 1909	109,091	"	0.165	
" "	Morris & Cummings D. Co.		21	*Oct. 15, 1910	129,412	"	0.12 4/11	
Keyport Harbor, N. J.	John H. Gerrish		8	*Dec. 17, 1910	89,385	"	0.179	Mud
Raritan River, N. J.	United States D. & Con. Co.		10	*Dec. 15, 1910	102,857	"	0.175	
South River, N. J.	" "		8	* "	53,512	"	0.299	Sand, mud and clay
Philadelphia, Pa.								
Delaware River	Atlantic, Gulf & Pacific Co.	New York, N. Y.	7	*Oct. 15, 1910	90,000	Place	0.12	
" "	" " "	" "		"	260,000	"	0.155	
" "	" " "	" "		"	370,000	"	0.24	
" "	" " "	" "		"	280,000	"	0.29	
" "	American Dredging Co.	Philadelphia	35	*Oct. 5, 1910	1,910,000	Scow	0.133	
" "	" " "	"		"	250,000	"	0.15	
" "	" " "	"		"	200,000	"	0.18	
" "	" " "	"		"	910,000	"	0.12	
" "	" " "	"		"	330,000	"	0.125	
Wilmington, Del.								
Racoon Creek, N. J.	River & Harbor Imp. Co.	Philadelphia, Pa.	7	*Dec. 8, 1910	88,262	Place	0.149	Mud, with some sand, clay and gravel
Salem River, N. J.	" " "	" "	9	*Dec. 29, 1910	70,475	"	0.194	Mud, sand, clay, gravel and debris
Tuckerton Ck., N. J.	Pennsylvania D. Co.	Camden, N. J.	6, 18	*July 21, 1909	44,826	"	0.25	Mud and sand
Mispillion R., Del.	The Rickards D. Co.	Philadelphia, Pa.		*Dec. 8, 1910	119,867	"	0.11	Mud, sand, gravel and some clay

TABLE I. CONTRACT PRICES FOR DREDGING DONE FOR THE U. S. GOVERNMENT, UNDER SUPERVISION OF THE CORPS OF ENGINEERS, U. S. A.—Continued

(Only contracts above 20,000 cu.yd. are included)
* = Date of contract. † = Date of approval of work

District and locality	Contractor	Address	Depth of dredging	Date of contract or approval	Estimated quantities, cu.yd.	Scow or place	Contract price, cu.yd.	Character of material Remarks
Baltimore, Md.								
Channel to Baltimore	Maryland D. & Con. Co.		35	†June 19, 1909	1,500,000		0.05	Soft material
" "	" " "			†Oct. 31, 1910	400,000		0.15	"
" "	" " "			†June 2, 1911	2,260,000		0.095	"
Southwest Baltimore	Sanford & Brooks Co.		22	†Oct. 17, 1910	310,000		0.0975	" silt
Elk River, Md.	Maryland D. & Con. Co.		4	†Oct. 18, 1910	47,000		0.185	Pumped upon adjacent marshes, suction dredge
Susquehanna R., Md.	" "		12	†Oct. 18, 1910	95,000		0.185	Clamshell dredge
Rockhall Harbor, Md.	" "		12	†Oct. 18, 1910	103,200		0.185	
Queenstown Harbor, Md.	" "		10	†Oct. 18, 1910	40,800		0.185	
Claiborne Harbor, Md.	" "		10	†Oct. 18, 1910	57,400		0.185	
Cambridge Harbor, Md.	" "		12	†Oct. 18, 1910	30,000		0.185	
Chester River, Md.	River & Harbor Imp. Co.			†July 6, 1909	37,700		0.1195	Clamshell dredge
Manokin River, Md.	Maryland D. & Con. Co.		6	†Oct. 18, 1910	67,200		0.185	"Mud Flats," suction dredge
Nanticoke River, Del.-Md.	" "		9	†Oct. 18, 1910	61,400		0.185	
Crisfield Harbor, Md.	" "		10	†Oct. 18, 1910	47,600		0.185	
Washington, D. C.								
Potomac River	Atlantic, Gulf & Pacific Co.	New York, N. Y.	21	*Oct. 15, 1910	1,500,000		0.0789	Soft mud
Anacostia River	" " "	" "	20	"	1,500,000		0.0689	Soft mud
" "	Sanford & Brooks Co.	Baltimore, Md.		*Sep. 19, 1910	80,000		0.15	
Potomac R., Alexandria	" "	" "	24	*Oct. 6, 1910	300,000		0.1175	
" "	" "	" "		*May 29, 1911	300,000		0.156	
Potomac R., L. Cedar Pt.	John H. Miller	Washington, D. C.	10	*Oct. 6, 1910	41,000		0.219	
Upper Machodoc Ck., Va.	" "	" "	7	* "	45,000		0.129	
Occoquan Creek, Va.	Maryland D. & Con. Co.	Baltimore, Md.	6	*July 30, 1910	50,000		0.182	
James River, Va.	Miner Engineering Co.	Washington, D. C.	18	*June 2, 1910	35,000	Place	0.28	Mud and sand, some gravel
" "	Coastwise D. Co.	Norfolk, Va.		*Nov. 5, 1910	1,739,000	"	0.06	Soft mud, sand, marine shells
Norfolk, Va.			[22					
Norfolk, Va.	Maryland D. & Con. Co.		25	*Oct. 4, 1910	69,032	Scow	0.995	
" "	Coastwise D. Co.		[30	*Aug. 6, 1907	8,241,895	"	0.073	Stiff mud and sand
Channel to Newport News	Morris & Cummings D. Co.		35		1,128,849	"	0.094	Stiff clay, sand and mud
" "	" "				1,960,000	"	0.1689	Stiff clay, some sand
Onancock River, Va.	Norfolk Dredging Co.		8	*Oct. 7, 1910	48,715	"	0.239	Fine compact sand, mud
Wilmington, N. C.								
Shallow Bag Bay, N. C.	Miner Engineering Co.	Washington, D. C.	6	*Oct. 31, 1910	40,000	Place	0.25	
Swan Quarter Bay, N. C.	" "	" "	6	*Oct. 31, 1910	53,000	"	0.195	
Bay River, N. C.	" "	" "	10	*Oct. 31, 1910	140,000	"	0.1275	
South River, N. C.	" "	" "	7	*Oct. 31, 1910	75,000	"	0.14	
Smiths Creek, N. C.	Mitchell & Co.	New York, N. Y.	10	*Dec. 5, 1910	130,000	"	0.105	
Pamlico Sound, N. C.	Maryland D. & Con. Co.	Baltimore, Md.	10	*Aug. 15, 1908	3,600,000		0.1075	
Beaufort, N. C.	Mitchell & Co.	New York, N. Y.	7	*Dec. 5, 1910	221,408	"	0.105	
Morehead City, N. C.	" "	" "	10	* "	152,000	"	0.105	
Cape Fear River, N. C.	Bowers Southern D. C.		26	*Nov. 14, 1910	1,050,070		0.0795	
Charleston, S. C.								
Winyah Bay, S. C.	Atlantic, Gulf & Pacific Co.		18	*June 5, 1911	1,795,585		0.099	Silt
Savannah, Ga.								
Savannah H., Ga.	P. Sanford Ross (Inc.)	Jersey City, N. J.	26	†Oct. 27, 1910	1,940,400		0.10½	Sand, clay and mud
" "	Home Dredging Co.	Mobile, Ala.		June 1911	1,600,000		0.116	
Darien & Doboy Bay, Ga.	P. Sanford Ross (Inc.)	Jersey City, N. J.	12	†Nov. 29, 1910	150,000		0.17½	
Club and Plantation Cks.	Savannah Eng. & Con. Co.	Savannah, Ga.	7	†Oct. 12, 1910	220,000		0.159	Through marsh
Brunswick Harbor, Ga.	P. Sanford Ross (Inc.)	Jersey City, N. J.		†Dec. 3, 1910	60,000		0.16½	
Inside Water Route	" "	" "	7	†Nov. 29, 1910	150,000	Place	0.17½	
Jacksonville, Fla.								
St. Johns River, Fla.	Roderick G. Ross		24	†July 15, 1909	278,000		0.14	Sand and mud
" "	" "			† "	25,000		0.40	Coquina
" "	" "			† "	91,600		0.14	Sand and mud
" "	Bowers Southern D. Co.	Galveston, Tex.	30	†June 19, 1911	5,486,200		0.104	
" " Jacksonville	P. Sanford Ross (Inc.)		24	†Oct. 6, 1910	44,000		2.64	Rock, rock breaker
Indian River, Fla.	Hillsboro D. Co.		5	†June 12, 1911	82,000		0.18	Sand
Caloosahatchee R.	Bowers Southern D. Co.	Galveston, Tex.	12	†Nov. 17, 1910	155,000		0.18	
" "	" " "	" "		† "	200,000		0.11	
" "	" " "	" "		†June 17, 1911	36,900		0.18	
" "	" " "	" "		† "	399,500		0.10	
Sarasota Bay, Fla.	Hillsboro D. Co.	Tampa, Fla.	5	†Jan. 28, 1911	177,550		0.125	
Hillsboro Bay, Fla.	Rittenhouse, Moore	Mobile, Ala.	23	†Oct. 25, 1910	1,200,000		0.085	Soft material
" "	North American D. Co.	Galveston, Tex.	24	†Oct. 24, 1910	1,500,000		0.0798	"
Anclote River, Fla.	Hillsboro D. Co.	Tampa, Fla.	6	†Nov. 5, 1910	241,500		0.1375	Dredging plant $175 per hour
Montgomery, Ala.								
St. Andrews Bay, Fla.	" " "	Mobile, Ala.	5	*Oct. 29, 1910	575,000		0.127	
" "	Home Dredging Co.	" "	22	*Oct. 19, 1910	160,276		0.1223	1000-ft. pipe line
" "	" " "	" "		*Mar. 10, 1911	173,255		0.1173	500- " " "
Mobile, Ala.								
Mobile Harbor	Atlantic, Gulf & Pacific Co.		27	*Oct. 11, 1910	2,071,000	Place	0.0590	
" "	" " "			"	981,000	"	0.084	

TABLE I. CONTRACT PRICES FOR DREDGING DONE FOR THE U. S. GOVERNMENT, UNDER SUPERVISION OF THE CORPS OF ENGINEERS, U. S. A.—Continued

(Only contracts above 20,000 cu.yd. are included)

* = Date of contract. † = Date of approval of work

District and locality	Contractor	Address	Depth of dredging	Date of contract or approval	Estimated quantities, cu.yd.	Scow or place	Contract price, cu.yd.	Character of material Remarks
New Orleans, La.								
Bayou Plaquemine	Charles Clarke & Co.	Galveston, Tex.	6	*July 15, 1899	1,027,509		0.1398	
Atchafala R., La.	Atchafalaya Bay S. C. Co.	Morgan City, La.	.....	*July 30, 1910	.....	.....	.....	Contract price $530,000
Galveston, Tex.								
Galveston Channel	L. T. Gaylord	Houston, Tex.	32	†May 19, 1911	4,200,000	.....	0.067	Mud, sand and hard red clay
Texas City Channel	" "	" "	25	†Oct. 28, 1910	1,153,500	.....	0.093	Soft material
Port Bolivar, Tex.	N. American D. Co. of Texas	Galveston, Tex.	30	†Nov. 5, 1910	777,000	.....	0.1075	
Brazos River	John Jacobson	Texas City, Tex.	5	†April 1, 1911	2,166,800	.....	0.0874	Matagorda Bay, 10¼ cents
Arkansas Pass-Corpus Christi	Bowers Southern D. Co.	Galveston, Tex.	12	†Oct. 20, 1910	1,000,000	.....	0.1374	
Duluth, Minn.								
Duluth, Minn.-Superior, Wis.	Duluth-Superior D. Co.	Duluth, Minn.	23	*April 28, 1910	156,075	.....	0.125	
" " "	" " "	" " "	.....	*Oct. 11, 1910	2,666,000	Scow, place	0.09	
" " "	Northern D. & Dock Co.	" " "	.....	June 19, 1911	120,400	Scow	0.17	
Ashland, Wis.	Zenith Dredge Co.	" " "	20	*May 1, 1911	139,134	"	0.115	Sand and soft material
Keweenaw Waterway	Northern D. & Dock Co.		20	*Aug. 19, 1910	101,640	.....	0.20	Red clay and quicksand
Marquette, Mich.	" " "		20	*Oct. 10, 1910	142,335	.....	0.19	
Milwaukee, Wis.								
Oconto Harbor, Wis.	Adolph F. Bues	Milwaukee, Wis.	16	*June 7, 1911	380,000	.....	0.11½	
Green Bay Harbor, Wis.	Greiling Bros. Co.		20	*May 20, 1910	83,325	.....	0.169	
Milwaukee, Wis.	William H. Gillen		20	.....	72,905	.....	0.17	
Chicago, Ill.								
Chicago River, Ill.	Great Lakes D. & Dock Co.	Chicago, Ill.	26	†Oct. 29, 1910	406,000	.....	0.35	Soft materials; $5.40 and $3.95 for rock
Calumet River, Ill. Ind.	" " "	" " "	21	†May 13, 1910	977,000	Place	0.228	Also: 27, 23.5 and 27.5 cents
Indiana Harbor, Ind.	" " "	" " "	22	†May 6, 1911	77,592	"	0.1975	In lake 25 cents, scow measurement
Michigan City Harbor, Ind.	" " "	" " "	18	†Jan. 22, 1910	147,129	Scow	0.109	
Grand Rapids, Mich.								
South Haven Harbor	" " "	" " "	16	*April 8, 1911	143,000	Scow	0.13½	18 cents, scow measurement
Saugatuck, Mich.	" " "	" " "	16	* "	107,475	Place	0.20	
Muskegon Harbor, Mich.	Adolph F. Bues		20	* "	128,000	Scow	0.155	
Detroit, Mich.								
Hay Lake, St. Marys R.	Lake Erie Dredging Co.	Buffalo, N. Y.	21	*Aug. 11, 1908	300,781	Bank	0.24½	Sand, clay, bowlders; 291,252 cu.yd. half rate
Saginaw River, Mich.	Breymann Bros.	Toledo, O.	18	*May 9, 1911	792,000	Scow	0.12½	
" " "	" " "	" " "	.....	* "	2,233,000	"	0.17	
Port Huron, Mich.	Muir-O'Sullivan D. & D. Co.	Port Huron, Mich.	16	*June 9, 1911	40,000	"	0.155	
Detroit River	Great Lakes D. & D. Co.	Chicago, Ill.	.....	*Oct. 31, 1907	260,967	"	1.98	Clay, hard pan, bowlders and bed rock
" "	Grant Smith & Co. and Locher	Grosse Ile, Mich.	.....	*Nov. 1, 1907	1,189,382	.....	1.24	Rock, 60 cents for earth
" "	P. B. McNaughton & O. E. Dunbar	Buffalo, N. Y.	.....	*Dec. 23, 1907	1,952,764	Bank	2.80	Rock, 50 cents for earth
Cleveland, O.								
Cleveland, O.	Great Lakes D. & D. Co.	Chicago, Ill.	25	*Oct. 24, 1910	163,812	.....	0.17	
Conneaut, O.	Breymann Bros.	Toledo, O.	21	*Sep. 6, 1910	275,173	.....	0.199	
Buffalo, O.								
Erie, Pa.	Central Dredging Co.		20	*Oct. 9, 1909	133,067	Scow	0.18	Fine sand, sand and clay
Black Rock Harbor	Empire Engineering Corpn.	New York	23	*Feb. 1, 1906	261,055	Place	0.33	Sand, mud, clay, gravel
" "	" "	" "	.....	"	269,733	"	1.85	Bed rock
" "	Buffalo Dredging Co.	Buffalo N. Y.	.....	*July 25, 1907	360,000	"	0.28	Sand, mud, clay gravel
" "	" "	" "	.....	"	279,000	"	2.70	Bed rock
" "	Great Lakes D. & D. Co.	Chicago, Ill.	.....	*Mar. 31, 1911	770,000	"	0.15	Sand, mud, clay, gravel
" "	" "	" "	.....	"	65,000	"	2.30	Bed rock
Niagara River	Arthur L. Vogel	Milwaukee, Wis.	23	*Aug. 25, 1910	580,000	"	0.22	Sand, mud, clay, gravel
" "	" "	" "	.....	"	190,000	"	2.05	Bed rock
Charlotte, N. Y.			18	.....	160,000	.....	.....	
Ogdensburg, N. Y.	Duluth Marine Con. Co.		19	.....	.....	.....	.....	
Los Angeles, Cal.								
San Diego, Cal.	Standard American D. Co.	San Francisco, Cal.	30	†Nov. 8, 1910	805,910	Scow	0.1489	
Los Angeles, Cal.	" " "	" " "	30	†Dec. 23, 1910	333,333	.....	0.42	Hard clay, soft rock in ledge
" "	Tacoma D. Co.	Tacoma, Wash.	20	†Nov. 15, 1910	2,200,000	.....	0.089725	
	Standard American D. Co.	San Francisco, Cal.	.....	June 28, 1911	350,000	.....	0.415	
1st San Francisco, Cal.								
Redwood Creek, Cal.	J. C. Franks		5	*Jan. 31, 1911	100,000	.....	0.0973	
Oakland Harbor, Cal.	San Francisco Bridge Co.		30	*May 4, 1908	1,916,700	.....	0.188	
" "	" "		.....	*Nov. 15, 1910	1,289,200	.....	0.114	
San Joaquin River, Cal.	Antioch Dredging Co.		9	*Sep. 23, 1910	257,000	.....	0.0689	
Stockton & Mormon Ch.	Standard American D. Co.		.....	*Aug. 15, 1908	834,100	.....	0.155	
Petaluma Ck. & Napa R.	N. R. Harris		6	*Nov. 9, 1910	65,307	.....	0.1174	
Seattle, Wash.								
Olympia, Wash.	Puget Sound Bridge & D. Co.		12	*Oct. 19, 1910	200,000	.....	0.108	
St. Michael Canal, Alaska	" "		6	*June 27, 1910	130,000	Place	0.90	Hard and soft mud, few bowlders
Hawaii								
Honolulu Harbor, Haw.	Hawaiian Dredging Co., Ltd.	Honolulu	35	*Nov. 23, 1910	162,000	"	0.77	
" "	Standard American D. Co.	San Francisco, Cal.	.....	1911	65,000	"	0.3475	
Porto Rico								
San Juan, P. R.	Standard Dredging Co.	Wilmington, Del.	30	.....	1,850,751	Scow	0.19	Soft material
" "	" "	" "	.....	.....	52,468	Place	6.80	Coral rock

TABLE II. DETAILS OF OPERATIONS, CONTRACTORS DREDGES, WASHINGTON, D. C., DISTRICT, YEAR 1910-1911

Locality	Contractor	Name of dredge	Working time	Days	Working hours	Material, cu.yd.	Hourly rate in cu.yd.
Potomac River, Washington Ch'l	Atlantic, Gulf & Pacific Co.	27-in. "Pittsburg"	Jan. 18, 1911 to June 2, 1911	136	2,155	1,365,562	634
Anacostia R.	Sanford-Brooks Co.	20-in. "Dewey"	Sep. 20, 1910 to Nov. 28, 1910	70	521	109,413	210
" " "	Sanford-Brooks Co.	Clam shell "Canton"	Dec. 1, 1910 to Dec. 13, 1910	13	78	7,111	92
" " "	Atlantic Gulf & Pacific Co.	27-in. "Pittsburg"	June 5, 1911 to June 30, 1911	26	388	295,964	761
Potomac River, Alexandria, Va.	Sanford-Brooks Co.	Clam shell "Canton"	Mar. 4, 1911 to April 15, 1911; May 2, 1911 to June 30, 1911	103	764	133,920	175
Potomac River, L. Cedar Point, Md.	John H. Miller	Clam shell "No. 6"	Mar. 6, 1911 to April 15, 1911	41	219	3,870	18
Potomac River, L. Cedar Point, Md.	John H. Miller	15-in. "Potomac"	Mar. 30, 1911 to April 27, 1911	29	342	35,297	103
Upper Machodoc C'k, Va.	John H. Miller	12-in. "Grey Eagle"	Nov. 17, 1910 to Dec. 13, 1910	27	303	61,305	202
Nomini C'k, Va.	Maryland D. & Contracting Co.	10-in. "Elk"	Oct. 1, 1910 to Nov. 8, 1910	39	314	8,574	28
Dymers C'k, Va.	John H. Miller	15-in. "Potomac"	May 11, 1911 to May 20, 1911	10	165	17,889	109
Occoquan C'k, Va.	Maryland D. & Contracting Co.	12-in. "Grey Eagle"	Sep. 5, 1910 to Nov. 11, 1910	68	794	73,354	92
Urbana C'k, Va.	Maryland D. & Contracting Co.	10-in. "Elk"	Aug. 23, 1910 to Sep. 24, 1910	33	275	20,061	73

TABLE III. COSTS OF DREDGING IN CAPE FEAR RIVER, N. C.

United States Name of Dredge and Kind	Time employed, days	Cu.Yd. dredged	Per day	Cost	Per cu.yd.
32-inch pipe line hydraulic dredge "Jacksonville"	365	688,558	2,541	$59,989	8.7+
Seagoing "Cape Fear"	164	373,500	3,012	22,157	5.9+
" "Comstock"	365	1,508,414	6,419	83,811	5.6—
Clam shell "Ajax"	365	542,027	....	39,963	7.4—
" " Hercules"	365	566,631	....	46,219	8.2
Totals	....	3,679,130	....	252,139	6.9
Powers Southern Dredging Co., hydraulic dredge, No. 9	194	1,050,070	....	66,287	6.3

of which was 10¼c. per cu.yd. for material removed from the prescribed cross-section and 5⅛c. for material removed from 1 ft. outside. The quantities removed are as follows:

Removed from prescribed cross-section	3,820,581 cu.yd.
Removed from 1 ft. outside	603,910 cu.yd.
Removed from outside cross-section (no pay)	1,436,256 cu.yd.
Completing 95,527 lin.ft. of channel.	
The cost of the work was as follows:	
Contract cost of dredging	$439,554
Main office expenses	9,881
Superintendence and surveys	16,672
Plant	3,667
Total	$469,774

The average cost of the material removed for the whole contract from the prescribed cross-section and 1 ft. outside is 10.6+c. per cu.yd.; including the amount dredged, for which no payment was made, the actual cost would be 8+c. per cu.yd.

In the Cape Fear River, 1,050,070 cu.yd. of material, sand, clay, mud and silt were removed, the average price being 6.3+c. per cu.yd. The contract price is 7.95c. for material from prescribed depths, and for 1 ft. below, one-half or 3.975c. (This practice obtains in a number of other harbors.) The Bowers Southern Dredging Co. did the work with a hydraulic dredge between Dec. 10, 1910, and June 30, 1911, a total of 194 days. This place affords a good comparison between contract costs and the cost of dredging with U. S. government plant, as shown by Table III.

At Winyah Bay the contract price is 9.9c.; the quantity is 1,795,585 cu.yd. At Savannah, Ga., the price is a little higher, 10½c. per cu.yd. for 1,940,400 cu.yd., and 11.6c. per cu.yd. for 1,600,000 cu.yd.

The Gulf division includes the harbors along the Gulf of Mexico, between Florida and Texas. The lowest price paid for dredging is in Mobile Harbor, which is 5.9c. per cu.yd.; in the Galveston channel the price was 6.7c. per cu.yd.; in the Brazos River, 8.74c. per cu.yd. and in the Texas City channel, 9.3c. per cu.yd. At the mouth of the Atchafalaya River, La., a channel 200 ft. wide and 20 ft. deep is being dredged by the Atchafalaya Bay Ship Channel Co., of Morgan City, La., for which the contractor received $530,000 in bulk.

In the Western and Central divisions, no contract dredging is done to any extent, if at all. The work is done there by the U. S. dredging plant or else by hired plants, as in the Ohio River.

Along the Great Lakes, which comprises the Lakes division, the most extensive contract dredging is at Duluth, Minn.; St. Marys, Saginaw and Detroit, Mich., and Buffalo, N. Y. Contract prices for earth range from 9 to 20c. per cu.yd. and more, and from $2.05 to $3.40 per cu.yd. for rock.

On the Pacific Coast the most important contract dredging operations are at San Diego, Los Angeles and Oakland, Calif.

Table IV shows the operations at Portland, Ore., with a 30-in. dredge "Columbia," owned by the Port of Portland, Ore., and leased to the United States government.

The cost of dredging per cu.yd. by the U. S. government sea-going dredge "Chinook," in the Columbia River, was 8.159c. per cu.yd. (see ENG. NEWS, May 9, 1912), but this does not include extraordinary repairs, office and other expenses. On the other hand, the low cost of the "Columbia's" dredging is on account of the low rental of $350 per day.

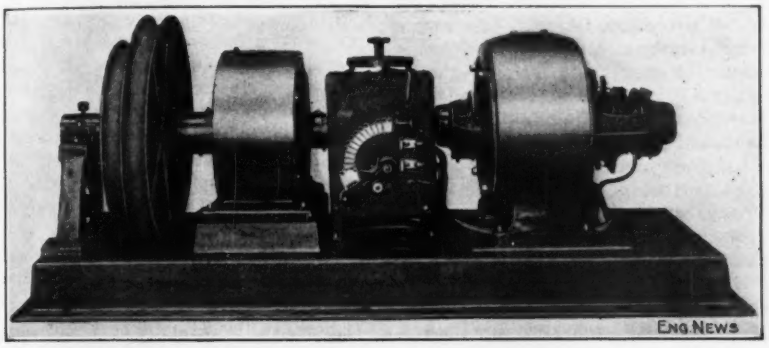
TABLE IV. PORTLAND, ORE.; DREDGING WITH HIRED 30-IN. HYDRAULIC DREDGE, "COLUMBIA"

Details of work	Time	April 1910	May 1910	June 1910	Total
Time dredging	hours	113	420	479	1,012
Allowable delays for repairs not to exceed 4 hr. per day for any month	hours	32	104	104	240
Delays for repairs	hours	47	64	39	149
Delays washing boilers, moving anchors, etc	hours	.....	37	2	9
Operating time	hours	192	624	624	1,440
No. of days worked	days	8	26	26	60
Cubic yards excavated (estimated)	cu.yd.	62,500	274,000	298,300	634,800
Cubic yards excavated (per day)	day	7,812	10,539	11,473	10,560
Cost, including inspection and shore work	$	3,335	9,878	9,771	22,984
Cost per cubic yard	cents	5.34	3.61	3.27	3.62

Electric Hoist for Foundation Work

In building construction work in large cities the use of steam operated hoisting engines is a source of considerable annoyance to the public (and especially to the tenants of adjacent buildings), on account of the noise, smoke and dirt which they cause. At the same time they cause the contractor some trouble in maintaining the fuel supply, since the engines are often located at points difficult of access. In the great amount of building construction and reconstruction which has been in progress in the business district of Chicago for the past few years, electric hoists have been employed in a number of cases to operate hoists, derricks, material elevators, etc., and they have been found of great advantage in this class of service.

A recent application of the electric hoist is in connection with sinking the deep pier foundations now commonly used for large buildings in Chicago.



ELECTRIC HOISTING MACHINE FOR DEEP FOUNDATION WORK; OPERATING SEVERAL HOISTS SIMULTANEOUSLY

[Thomas Elevator Co., Chicago; Builders]

Under this system open circular wells (locally known as "caissons") are excavated in the clay to reach rock or hardpan at depths of 80 to 100 ft. The wells are lined with wood, braced by interior steel rings, and when completed they are filled with concrete, forming supports for the steel columns of the superstructure (and sometimes forming the columns of the lower basements). The ordinary method of operation is to rig over each well a head frame of four timbers meeting in a point and carrying a sheave directly over the well; at one side is a short shaft having a winch or nigger-head on one end and a friction sheave on the other end.

A hoisting engine placed at one end of a line of wells operates a cable which is led over all the sheaves and runs continually. The bucket rope at each well is wound loosely upon the drum (which revolves continuously), and then passes up to the sheave in the head frame, from which it drops into the well. To hoist the load the man at the top draws this rope tight upon the drum to obtain the necessary friction. The running cable is operated usually by a double-cylinder double-drum steam hoisting engine, which must be equipped with a governor and throttled to such an extent that it cannot develop anything like its full or rated capacity. If men at several of the wells simultaneously start to raise loaded buckets the combined load may be too great for the reduced efficiency of the engine, and some of the hoisting lines must be snubbed or released temporarily.

The electric caisson hoist mentioned above, and shown in the accompanying cut, has been designed specially for this class of work. It is of greater efficiency under the conditions noted, and is free from the objectionable features incident to the use of steam, while it takes up less room than the steam hoist and boiler. The hoist consists of a 35-hp. compound-wound motor, directly connected to a reducing gear and equipped with a field control with which the speed of the motor can be varied 20%. On the reducing-gear end a cable sheave is attached, which drives the running cable. The entire outfit is mounted on a cast-iron bedplate. With this outfit all dirt and noise are eliminated, the full power is available at all times, and it is stated that a greater number of wells can be worked with this plant than with a steam plant of corresponding size. This electric caisson hoist is one of the specialties of the Thomas Elevator Co., of Chicago.*

The hoist has been used already on three important works at Chicago. It was employed by the Henry Ericsson Co. for the foundation work on the Webster Bldg. and the Westminster Bldg.; on this latter building as many as 14 wells were operated at one time, but without causing the hoist to reduce its speed. It is now in use by the Falkenau Construction Co. for the foundations of the new Goddard Bldg., which will require about 20 wells. Ten wells are being sunk simultaneously, in two rows, the running cable being diverted by means of guide sheaves. No trouble is experienced, the plant working smoothly and silently. On this work a motor-driven fan is used to blow air into the wells for ventilation, as gas pockets are sometimes encountered in the Chicago clay. A rather exceptional amount of water is encountered at this site, and so far this has been raised in buckets by the electric hoist. Pumps are being installed, however, so that the excavation may proceed without interruption.

*The same company's electrically operated multiple-spool hoist for operating several wells by independent cables, instead of by the usual running cable and separate bucket ropes, was described and illustrated in our issue of Feb. 2, 1911.

A Test of Electric Air Drills in Tunnel Driving in Japan

A hydroelectric power plant, which is to develop 60,000 hp. from the rapids of the Kinu River, is being built near Kurobe, Japan, by the Kinugawa Hydro-Electric Power Co., of Tokyo. The project involves a concrete dam 200 ft. in height and a conduit 8½ miles long from the storage reservoir to the power house in which the estimated flow is 700 cu.ft. per second. The available head at the power house will be about 1020 ft. Construction was begun in April, 1910, under direction of Messrs. Toshimitsa and Kobayashi, managers of the company, with Prof. Hiroi, consulting engineer in charge. It is expected that the work will be finished early next year.

There are twenty-five tunnels on the line of the conduit, which have to be driven through very hard rock. They have a cross-section 7x8 ft. A regular compressed-air equipment vas at first installed for driving some of these tunnels, but the expense of transporting and erecting the machinery decided the engineers to install electric air drills for part of this work, and thirty-two Temple-Ingersoll electric air drills are now at work. Careful tests of these drills have been made and in tunnel No. 20 in a ten-day trial run, an average advance of 12 ft. per day of three eight-hour shifts was made, or a total of 120 ft. in ten days. This work was done with two No. 4E Temple-Ingersoll drills.

The pulsators which furnish air for the drills were run into the tunnel on two 18-in. gage tracks. The drills were mounted on standard mining columns. The explosive used was 70% dynamite, the consumption averaged 100 lb. per 24 hours. The rate of drilling progress reached from 1.12 ft. per 10 minutes to 2 ft. In another tunnel driven through somewhat softer rock, the rate of advance of the tunnel averaged 15 ft. per 24 hours.

We are indebted for the above information to Mr. Chas. A. Hirschberg, of the Ingersoll-Rand Co., who obtained the data from T. Yokoyama, civil engineer with the Kinugawa Hydro-Electric Power Co.

Simplifying Some Engineering Calculations

By Carl Hering*

The writer has repeatedly urged that engineers ought to pay more attention than they do, to the efficiency of their own mental labor in their daily calculations, that is, to what might be called the conservation of their own mental energy. In a number of recent papers† the writer has pointed out how in different cases our daily engineering calculations could be simplified and reduced, and sometimes considerably, by expressing the numerical results in terms of such units as will avoid as much as possible those numerous cumbersome and troublesome conversion factors.

For instance, energy and power remain as such whether they are in the electrical, mechanical, thermal, chemical, physical (change of state), magnetic, luminous, or other state, although in many cases in practice their forms change from one to another. A good illustration is an electric furnace run from a steam-power plant; first the energy is chemical in the coal, then thermal, then physical (change of state), then mechanical (expansion), then electrical, then magnetic (in the transformer), then electrical again, then thermal again, then generally chemical and physical again, and partly also luminous.

According to our old system of calculations most of these different forms of the same energy and power are expressed and measured in different units specific to that particular form, as for instance in foot-pounds, kilogram-meters, gram-centimeters, gram calories, kilogram calories, thermal units, the hybrid pound-centigrade units, ergs, joules, watt-hours, horsepower-hours, kilowatt-hours, lumen-hours, spherical-candle-hours, etc., for energy, and in horsepowers (English and metric), kilowatts, watts, besides all the above energy units per hour, per minute or per second, etc., for power. Hence it often becomes necessary in the old system of calculations to keep changing the units in our calculations as the energy or power changes its form, although it is always the same energy or power. This is certainly not a rational or efficient use of mental effort; it is an entirely useless waste of brain work and is conducive to errors.

The general principle urged by the writer has been to use as far as practicable only one unit for each physical quantity (including, of course, decimal multiples like watts and kilowatts) and to select, for this unit, the one in the absolute or c.g.s. system, or some decimal multiple of it (preferably an already existing one) just as the electric units all are. Practically all the troublesome conversion factors then drop out of the calculations, for in this system they nearly all are unity (or decimal multiples). There is no mechanical equivalent of heat, or conversion factor for transforming electric into mechanical or thermal energy, etc., as all these factors then become unity, or multiples of 10. In such a system all forms of power are represented in watts or kilowatts, and all forms of energy (including thermal, chemical, mechanical, etc.) in watt-hours or kilowatt-hours. Some conversion factors must, of course, be used to bring into this simple system data which were originally given in the older ones (except the electrical) but this need be done only once at the start, all subsequent calculations made within that system being then free from further conversion factors. This simple system may be said to be a sort of international clearing house for such quantities, in which all the heterogeneous and incommensurate quantities can be exchanged after they have all been brought to a uniform basis.

The purpose of the present article is to supplement the above mentioned papers by answering a question recently asked, about the application of this simplified system to water- and steam-power calculations. Hydraulic power is now almost universally converted into electric power, hence why not designate it at once in terms of this simplified system of units, namely in kilowatts and thereby save all further reductions? Even if not used for electrical purposes it is often desirable to reduce all such powers to a common basis for comparison, and it will probably not be denied that of all the power units the kilowatt is the more usual today and the most rational one.

Water powers, in the form of water, are usually measured in terms of the product of the fall in feet and the cubic feet of water per second (the amount per minute gives in most cases unnecessarily and cumbersomely large figures); or as the product of the fall in meters and the cubic meters per second. This product must then be multiplied by the weight of a cubic foot or cubic meter of water, and as there is no power unit in these terms it must be again multiplied by another constant to reduce it to horsepowers and afterward by still another to reduce it to kilowatts. Hence it certainly involves no more work to use a single but numerically different constant in order to reduce the result to kilowatts directly. These constants to and from this simplified system are as follows, the assumed weight of water being the regular standard international constant, namely one kilogram for one cubic decimeter.

In order to specify clearly what is meant in the table, the numerical product (feet fall × cubic feet per second) will here be designated to be in terms of *"water-power units,"* and the product (meters fall × cubic meters per second) will be designated as being in terms of *"metric water-power units."* The conversion factors are then as follows:

1 water-power unit = 0.0846357 kilowatt.
1 kilowatt = 11.8153 water-power units.
1 metric water-power unit = 9.80597 kilowatts.
1 kilowatt = 0.101979 metric water-power unit.

The following approximate factors will generally suffice:

Dividing the product: (feet fall × cubic feet per second) by 12 gives the kilowatts (the error is less than 2%).

Multiplying the product: (meters fall × cubic meters per second) by 10 gives the kilowatts (the error is slightly over 2%).

Engineers, other than electrical, are apt to complain that the electrical engineers want all others to abandon the various inherited units of other branches of engineering, and to adopt what the other engineers are inclined to term the "electrical units," thus implying a selfishness on the part of the electrical engineers. This, however, is neither just nor correct when applied to the kilowatt (power) and the kilowatt-hour (energy), as they are quite as specifically mechanical units or thermal units as are foot-pounds, horse-powers, calories, etc. The kilowatt is merely a decimal multiple of the absolute or c.g.s. unit of power, and the latter system of units is characterized by having *only one* unit for each physical quantity; this unit is the erg for energy no matter what form the energy is in, and the erg per second for power irrespective of its physical form. The kilowatt is, therefore, just as truly a mechanical or thermal unit as it is an electrical one.

This can be shown by the following definition of a kilowatt, which it will be seen is based purely on mechanics:

A kilowatt is that power which is developed by a certain force acting at the rate of a meter per second, this force being equal to one which, if acting on a mass of one kilogram for one second, would produce a velocity of one kilometer per second.

Numerically this force is therefore equal to 10^3 dynes, or to 101.979 kg. or 224.825 lb. The unfortunate fact that this is an odd number of kilograms is due to the dyne and gram being incommensurate, as they are connected by the acceleration of gravity which is a terrestrial constant. This incommensurate relation between the unit of force, the dyne, on which energy is based, and the unit of mass, the gram, on which mass (hence weight) is based, appears to be the only conversion factor in the absolute system which is not unity. If this ter-

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†Uniformity and Simplicity of Electrochemical and Electrothermal Calculations. Amer. Electrochem. Soc., April, 1912; Simplification of Electrothermal Calculations; The Watt and The Thermal Ohm. Proc. Am. Inst. E. E., June, 1912; Simplifying Thermal Calculations by use of the Thermal Ohm. Jour. Franklin Inst., December, 1911; Simplicity in the Measures of Physical Quantities. Jour. Franklin Inst., February, 1911; Thermal Resistance and Conductance; The Thermal Ohm and the Thermal Mho. Met. & Chem. Eng., January, 1911.

restrial constant of gravity had been just 10 instead of 9.805966 meters per second, then even this, the only incommensurate conversion factor, would have disappeared from this otherwise admirable and exceedingly simple and well adapted system of units. It will be noticed that this incommensurate figure (or its reciprocal) appears in the above definition and in the above table, and is the only cause of those figures not being multiples of 10 in the metric system.

In a water power, the falling water is really acting as a force through a distance, hence should, in a rational system, be expressed and measured as a force, as distinguished from a weight, and if the original data are at once reduced to true units of force in the c.g.s. system the conversion factors virtually fall out of all subsequent calculations by becoming a decimal. As the c.g.s. unit of force is inconveniently small the practical unit is made one million times as great and called a megadyne (equal to 1.01979 kg. or to 2.24825 lb.).

A kilowatt is then equal to a force of 100 megadynes acting at a velocity of one meter per second. Hence in general:

1 kilowatt = 100 (megadynes × meters per second)

1 (megadyne × meter per second) = 0.01 kilowatt.

This shows how simple the calculations become in this system.

The following constants, which should be given in reference books, give the forces exercised by water:

1 cu.m. of water exerts a force of 980.597 megadynes.

1 cu.ft. of water exerts a force of 27.7676 megadynes.

1 megadyne = force exerted by 0.00101979 cu.m. of water.

1 megadyne = force exerted by 0.0360132 cu.ft. of water.

It will probably be argued that to convert the volume of water into a force merely shifts the troublesome conversion factor to a different part of the calculation. That is true in this particular case, but in general by thus shifting those troublesome factors to earlier parts of calculations, or perhaps into constants contained in tables, they may be disposed of in the original data, thereby leaving all the subsequent calculations, which may be the more numerous, free from conversion factors other than decimals.

In general it is advisable whenever practicable to reduce all the original data at the start into the simple system, particularly when it is in the form of tabulated constants, so as to enable the numerous subsequent calculations to be made as free from conversion factors as possible in the simple system.

If, for instance, the values in the tables of steam pressures for different temperatures were reduced once for all to megadynes per square centimeter instead of kilograms per square centimeter, then the calculated power of engines would be given directly in kilowatts without any troublesome reduction factors. This is a case in which the calculations are actually reduced, because with the older units the kilogram-meters per second must be multiplied by an incommensurate constant to reduce them to horsepowers or kilowatts.

If such tabulated steam pressures in kilograms per square centimeter be multiplied once for all by 0.980597 they will be in megadynes per square centimeter, hence will be reduced to the simple system after which there are no more conversion factors other than the multiplier 100, for calculating the kilowatts directly, for if the piston speed is given in meters per second and the total force in megadynes is obtained by multiplying this new pressure by the area in square centimeters, then the product of this force and the meters per second divided by 100 as stated above, gives the kilowatts directly.

When the pressures in tables are given in pounds per square inch, then multiplying them once for all by 0.135573 brings them into the simple system, as this constant combines all the conversion factors, so that when this new pressure is multiplied by the area in square inches (not square centimeters) and by the speed in feet (not meters) per second and divided by 100 it will give the power in kilowatts directly.

These illustrations show how the troublesome conversion factors may be disposed of once for all in the tabulated data.

What was said above concerning the kilowatt applies equally well to the kilowatt-hour, with the one exception that in practical work the hour is universally used as the unit of time instead of the second, which is the unit in the c.g.s. system. It is, of course, unfortunate that the hour was not made a decimal multiple of the second, or both decimal fractions of a day, but to change this would be so revolutionary that it would be useless to urge it at the present time; while to adopt the hour as the practical unit conforms with present enginering practice, hence involves nothing revolutionary.

Adopting the hour as the unit in engineering practice, hence the kilowatt-hour or the watt-hour as the unit of energy, instead of the joule (watt-second), means that very many calculations are simplified for the engineer while only a few are increased for the physicist, and as the former are by far the more numerous, it conduces to the conservation of mental energy of the majority to adopt the hour instead of the second.

It will therefore simplify many engineering calculations if all quantities of energy, be they mechanical, electrical, chemical, thermal, physical, etc., be expressed in watt-hours or kilowatt-hours; this unit therefore supersedes the various heat units also. In many cases this can be done by merely changing the physical constants in tables once for all to watt-hours, thus bringing the basic figures directly into this simplified system. Specific and latent heats, for instance, are then given directly in watt-hours per pound or kilogram instead of relatively to water.

Those working only in a very narrow and specific field dealing with never more than one form of energy may not be interested in any advantages to the profession at large and may prefer to adhere to their older units which are sometimes well adapted to such a limited sphere of calculations; but those like the electrical, steam, hydraulic, thermal and electrochemical engineer who deals with the larger and broader fields in which energy is transformed from one kind to another, will often be able to increase their mental efficiency by using this simpler system of only one unit for each physical quantity and making that unit a decimal multiple of the corresponding one in the c.g.s. system.

The following table of conversion factors contains in classified form those for reducing the older and more commonly used units to those of this simplified system. For further constants and for the reciprocals of most of these see the writer's other articles and his Conversion Tables. They are all given uniformly to six places of significant figures in order to conform with the rest of the more complete set which are all calculated on the same basis, and are, of course, accurate only in so far as the fundamentals are correct; these fundamentals are: gravity 980.5966; one kilogram calorie = 426.900 kilogram-meters; one cubic decimeter of water weighs one kilogram; density of mercury 13.59593; besides the official U. S. Standards.

POWER

General

1 watt = 10,000,000 ergs per sec.

1 kw. = 1000 watts.

Mechanical

1 gram-centimeter per second = 0.000,098,059,7 watt.

1 ft.-lb. per sec. = 1.355,73 watts.

1 kg.-meter per sec. = 9.805,97 watts.

1 megadyne-meter per sec. = 10 watts.

1 kilowatt = 100 megadyne-meters per sec.

1 metric hp. = 0.735,448 kw.

1 hp. = 0.745,650 kw.

1 (ft. fall × cu.ft. of water per sec.) = 0.084,635,7 kw.

1 (meters fall × cu. meters of water per sec.) = 9.805,97 kw.

Thermal, Chemical, Physical, Etc.

1 gram-calorie per second = 4.186,17 watts.

1 B.t.u. per min. = 17.581,6 watts.

1 lb.-centigrade heat unit per min. = 31.646,9 watts.

1 kg.-calorie per minute = 69.769,5 watts.

ENERGY

General

1 erg = 1 dyne-centimeter.

1 watt-sec. = 10,000,000 ergs or dyne-centimeters.

1 watt-hr. = energy of 10,000,000 ergs per sec. during one hour.

1 kw.-hr. = 1000 watt-hr.

Mechanical

1 gram-centimeter = 980.596,6 ergs.
1 ft.-lb. = 0.000,376,591 watt-hr.
1 kg.-meter = 0.002,723,88 watt-hr.
1 megadyne-meter = 10 watt sec.
1 (ft. fall × cu.ft. of water) = 0.023,-509,9 watt-hr.
1 (meters fall × cu. meters of water) = 2.723,88 watt-hr.
1 metric hp. = 735.447 watt-hr.
1 hp.-hr. = 745.650 watt-hr.

Thermal, Chemical, Physical, Etc.

1 gram calorie = 4.186,17 watt-sec. or 0.001,162,82 watt-hr.
1 B.t.u. = 0.293,027 watt-hr.
1 lb.-centigrade heat unit = 0.527,448 watt-hr.
1 kilogram calorie = 1.162,82 watt-hr.

FORCE

1 dyne = 1,019,79 milligrams.
1 megadyne = 1,000,000 dynes.
1 megadyne = 2.248,25 pounds.
1 megadyne = 1.019,79 kg.

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1 gram = 980.597 dynes.
1 pound = 0.444,791 megadyne.
1 kg. = 0.980,597 megadyne.
1 cubic foot of water (downward force) = 27.7676 megadynes.
1 cubic meter of water (downward force) = 980.597 megadynes.

PRESSURE

1 barie = 1 dyne per sq.cm.
1 megadyne per sq.cm. = 1 megabarie.
1 megabarie = 1,000,000 baries.

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1 gram per sq.cm. = 980.597 dynes per sq.cm.
1 m.m. of mercury column = 1,333.21 dynes per sq.cm.
1 ft. of water column = 0.029,888,6 megadyne per sq.cm.
1 in. of mercury column = 0.033,863,7 megadyne per sq.cm.
1 lb. per sq.in. = 0.068,942,5 megadyne per sq.cm.
1 m. of water column = 0.098,059,7 megadyne per sq.cm.
1 kg. per sq.cm. = 0.980,597 megadyne per sq.cm.
1 atmosphere (760 m.m.) = 1.013,24 megadynes per sq.cm. (megabaries).

THERMAL RESISTANCE

General

Thermal ohms = centigrade degrees ÷ watts = degrees per watt.
1 thermal ohm = a resistance requiring 1° C. per watt of heat flow.
1 thermal ohm = 0.000,000,1 c.g.s. unit of thermal resistance.
1 gram calorie unit = a resistance requiring 1° C. per flow of a gram calorie per second.
1 gram calorie unit = 0.238,882 thermal ohm.
1 c.g.s. unit = a resistance requiring 1° C. per flow of an erg per sec.
1 c.g.s. unit = 10,000,000 thermal ohms.

Thermal Resistivity

1 gram calorie (cm. cube unit) = 0.238,882 thermal ohm (cm. cube unit).
1 gram calorie (cm. cube unit) = 0.606,762 thermal ohm (cm. cube unit).
1 thermal ohm (cm. cube unit) = 2.540,01 thermal ohm (cm. cube units).

To reduce thermal conductivities to resistivities take their reciprocals. To reduce thermal conductivities given in B.t.u. per hr., per sq.ft., per in. thickness, per degree F., to thermal ohms (cm. cube units), multiply the reciprocal of that number by 693.455.

Pier Settlement on the Una Bridge, Grand River, Colo.

In order to obtain confirmation or denial of some sensational newspaper reports of the failure of a state bridge across the Grand River, near Una, Colo., we wrote for information to Charles W. Comstock, State Engineer of Colorado. Mr. Comstock has sent us some photographs and a description of the bridge from which the following account of the bridge and the pier settlement has been prepared.

The Grand River is the largest stream in Colorado. It flows in a general southwesterly direction for a distance approximating 280 miles before reaching the Colorado-Utah line. For this entire distance it flows through a narrow valley, at few places exceeding two or three miles in width, and for much of its length nothing more than a cañon. Una, the site of the bridge in question, is about 75 miles from the state line, and the drainage area of the river above it is between 6000 and 6500 square miles. The discharge at the bridge site varies from a little more than 300 cu.ft. per sec. at low-water periods to upward of 30,000 cu.ft. per sec. during the flood season. At high water the mean velocity is from 10 to 14 ft. per sec.

The river bed is formed in a mass of boulders and débris washed down from the hills above and extending to an unknown depth. Some idea of its character may be obtained from Fig. 1, taken at low water. No place within reach at any cost which can be considered for a country highway bridge is there any solid rock in place, hard pan, or any consolidated, compact stratum which can be depended upon to resist the erosive action of the river at high-water stages.

At depths varying at different points along the river from 3 to 12 or 15 ft. is found a stratum of boulders from ½ cu.ft. to 20 or 30 cu.ft. in size. This stratum is of unknown thickness and the character and depth of the underlying material are equally unknown. Since the boulders are of all sizes and more or less interlocked, excavation through this stratum is difficult and expensive. To drive piles through it is impossible. The State Engineer, Mr. Comstock, states that his best information is to the effect that all the bridge piers in the river, railroad and highway alike, as well as several diversion dams and other structures, are founded on this boulder stratum. In short, it has been generally considered the best foundation to be had.

When bids for the construction of the Una bridge were invited, the State Engineer had reason to believe that the elevation of this stratum was about 98 (high water 110), and the bidders were, therefore, instructed to make their bids include all masonry above that elevation, naming a unit price for masonry below it, which unit price should include necessary additional excavation. The boulder stratum was not actually encountered until the excavation for the river pier reached elev. 93. At this place the boulders were found to be so tightly wedged together that it was impossible to drive a pointed bar more than a few inches into any of the interstices. All fine and loose material was carefully removed, the spaces filled with concrete and the pier carried up to a total height of 22 ft. In Fig. 1 about one-half of the height of the pier is visible. The extra concrete placed in the pier foundation was nearly 50 cu.yd., and its cost at the agreed unit price was $1200. The extra concrete required in the foundations of the abutments brought the total payment for extra work on the bridge up to $2390.76, 10% of the contract price for the work.

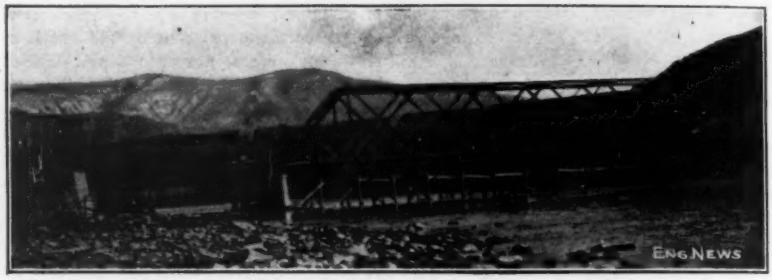


FIG. 1. UNA BRIDGE, GRAND RIVER, COLO. VIEW TAKEN DURING CONSTRUCTION

(Very low water in river. North abutment and pier at left.)

The bridge was completed in January, 1911. About the middle of May, 1912, the State Engineer was advised that one end of the pier had settled. An examination by one of the engineers from his office showed that the upstream end of the pier had settled 4 in., the other end remaining undisturbed. This was on May 18. The County Surveyor of Garfield County stated then that he had taken the elevation of various points on the bridge in December, 1911, and found the same condition which the State Engineer's office found the following May. This had not been reported to the State Engineer's office. At the time of its examination the river was high and rising rapidly. Noth-

ing could be done until the high-water period had passed, and while the necessity for repairs was obvious there appeared to be no immediate danger of losing the bridge.

On May 28 the State Engineer was advised that the upstream end of the pier was again sinking. A pile bent was then driven as near as possible to the pier and the truss span jacked up on that. The pier continued to sink slowly for several days and then came to a stop, but badly tilted out of position. The piles could not be driven to more than 7½ ft. penetration. The water was 17 ft. deep and there was, therefore, no possibility of sway bracing the bent. The velocity of the water exceeded 12 ft. per sec. and in about a week the pile bent was carried away and the truss span dropped back onto the pier. There it still stands, its entire weight being carried on two diagonally opposite corners, one on the pier and one on the south abutment.

The damage to the steel work is slight. If the bridge retains its present position until the river drops to its normal stage the cost of reconstruction will be only a little more than the cost of a new pier.

Figs. 2 and 3 show the condition of the bridge on May 30, when the pile bent was under construction.

Mr. Comstock says further: "The immediate cause of the failure is obvious. The pier foundation was not carried beyond the scouring effect of the river current. The reason for this was an attempt on the part of the writer to draw a line between the absolute stability and permanence which all engineering structures should have, and a cost of construction which the public funds could afford. To that extent I gambled—and lost."

A formal statement of bids, expenditures and other data on the Una bridge was printed in the 1909-10 report of the State Engineer.

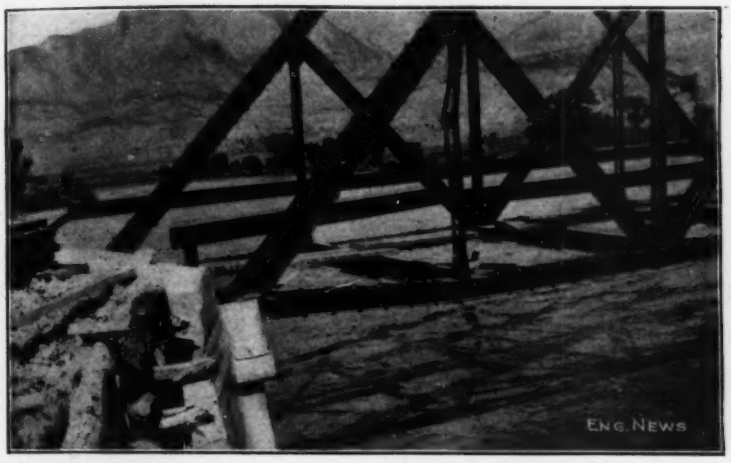


FIG. 2. SOUTH ABUTMENT AFTER SETTLEMENT OF NORTH PIER

FIG. 3. NORTH PIER SETTLEMENT

Why High Class Freight Cars are Economical*

It has been shown in these columns that the average freight car is repaired once a month during its life. Taking all kinds of repairs throughout its existence in service, it does not seem unfair to estimate the average loss of time at each repair at one week. Some who are quite familiar with the business and have thought the matter over carefully, say that this estimate is much too small. But on this basis, the average car loses one-fourth of its time in waiting for and undergoing repairs and in returning to service.

A railway manager is, let us suppose, to order a thousand cars. He gets bids on an average cheap construction, with arch-bar trucks, wooden underframing or an ill-designed and cheap steel underframe, iron wheels, spring draft gear, etc., etc., using for door, roofs and all specialties the cheapest things which he thinks may possibly do, because he has used them and others are still using them. He also takes bids on an uptodate car which is as nearly 100% design and construction as the present state of the art admits, and is certainly designed throughout to meet with engineering skill the stresses of modern service, which, as has been well said, are as great as the shocks of collision ten years ago.

He will find possibly that his lowest bids on the latter car will be a hundred dollars higher than those on the inferior or average car. For the same money he can get at least 10% more of the latter type of cars than of the former. The question then is as to buying, say, 1000 of the higher grade cars or 1100 of the cheaper for the same money. He needs, he thinks, all the cars he can get. How will it work out?

If he buys the 1100, statistics show that they will lose one-fourth their time undergoing repairs. He will, therefore, have, on the average, 825 cars in service. The better car will not, during its life, need repairs, at the outside, more than half as often; and would, therefore, lose only one-eighth its time in that way. Of the thousand he would have 875 in service, on an average, through their life. On the service basis only, therefore, he would actually have 50 more cars by buying the 1000 than by buying the 1100. These comparisons are moderate—we believe they would actually show a greater difference. The same problem arises in making heavy repairs to old cars: as between using improved appliances and materials, and the policy of never making any part of the car better than it was originally.

That the use of steel underframe of good engineering design, steel wheels, steel side truck frames adequate draft gear and the best doors and roofs and brake beams obtainable will not only cut in two the number of times a car is repaired but also the cost of repairs is beyond dispute. Such a car ought not to cost, and we believe does not cost an average of $40 a year for repairs; while the average car now in service costs more than twice that amount.

But in this argument we are leaving out cost of repairs, value of lost time, cost of hauling dead weight, loss and damage to freight, delays of traffic due to failures on the road, wrecks caused by defective cars, etc. The one fact, which it seems to us cannot be successfully denied, is that the buyer actually gets more cars by buying the thousand than he does by buying 1100 for the same gross amount of cost.

*From the "Railway and Engineering Review," June 29, 1912.
See also the discussion on this subject before the Master Car Builders' Convention, at Atlantic City, June, 1912, in Engineering News, June 20, 1912, p. 1199.

Automatic Block Signaling for Single-Track Railways

By James B. Latimer*

Trains were moved by block signals of one sort or another early in the history of railroading in Europe, but from various causes (of which the public has heard a good deal recently) their introduction into American practice has been very slow. The high cost of labor in this country early brought out inventors of many automatic systems, some of which showed remarkable ingenuity if not practicability. Thus, one of the earlier ideas was a tube much like a huge thermometer, into which a passing train pumped a colored liquid, the return flow of which was graduated as to time so that a following train could tell by its height how many minutes ahead of it the last preceding train had passed the signal. Then came clockwork signals, and at last the track-circuit idea was developed, which last has been the universally accepted practice in automatic-signal work for more than a quarter of a century.

The introduction of automatic block-signal working on European railways has been much slower than the introduction of any system of blocking on American roads. In fact, today automatic blocking in Europe may be said to be confined to a few sample installations installed principally for experimental purposes. The reasons for this condition no doubt are as follows: 1, almost all European roads were operated entirely by manual block signals when automatics were first thought of; 2, this method of blocking has been remarkably successful in Europe, so that there has been no public demand for anything else; and 3, the cost of labor being low, manual blocking could be operated at a less cost than the interest and depreciation on an automatic investment would involve. The condition in America may be said to be exactly the reverse, so that the tendency toward the use of automatic block signals has been much more pronounced here than in Europe.

After the practicability of the use of automatic block signals become a recognized fact, it was soon apparent that they could be used very advantageously on double track, but their value for single-track practice was much more difficult to establish. By far the greater proportion of American railway mileage is single track, and this condition is likely to continue for many decades. It is safe to say that, on an average, passing tracks are at least six miles apart. On double track there is no necessity to maintain operators. Of course, it is a convenience to have them at passing tracks, to handle the switches by which trains enter and leave these tracks and to receive and deliver such orders as the dispatchers may wish to issue to trains on the road. But a double-track railway equipped with automatic block signals could be operated from terminal to terminal, without employing any operators. To be sure, in the case of derailments, breakdowns, doubling hills with heavy trains, etc., serious delays to traffic would occur; but as far as safety is concerned, the road could be so operated.

With single track the problem changes. Regular trains might be handled in this way if they could be kept always on time, but the fluctuating nature of the traffic requires the frequent running of extra trains. If there were no operators stationed along the line, it would be impossible for a dispatcher finding it necessary to send out an extra to notify any regular trains then on the road and running in the opposite direction where to meet and pass the extra. Of course, the signals would be arranged so as to guard against an actual head collision, but, as far as the science of automatic blocking for single track had advanced up to very recently, it would be impossible to prevent a likelihood of the trains meeting midway between passing tracks. In such event, one or the other would have to back up, possibly encountering another following train, which would have to back up also, thus creating a condition of chaos over the entire line.

It might be argued that this could be prevented by making the blocks long enough to extend from passing track to passing track, with no intermediate signals, but such an arrangement would afford so little protection against rear collisions (unless an absolute block was maintained between passing tracks) that it would soon have to be abandoned. If the absolute block was maintained from passing track to passing track, each block would (as before stated) average certainly six miles in length; and this, with the number of trains handled on many of our single-track lines, would render it impossible to get the traffic over the road.

Single-track automatic block-signal systems, therefore, up to now, have been used solely as an adjunct to the dispatching system. As it was found impossible to reduce appreciably the number of operators employed, when the automatics were installed, a road installing them simply added the interest on the investment to its fixed charges, and the depreciation and cost of maintenance to its operating expenses, without any corresponding credit except the indefinite one of insurance against collisions. Unfortunately, through the recklessness of trainmen and enginemen or the occasional failure of the apparatus, collisions continue to occur in automatic territory, so

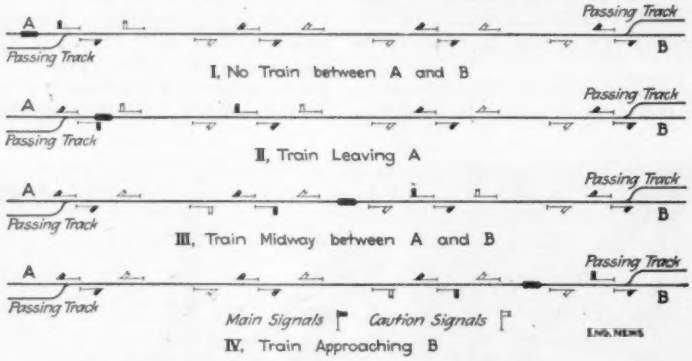


Fig. 1. Diagram Showing Former System of Block Signals on Single Track

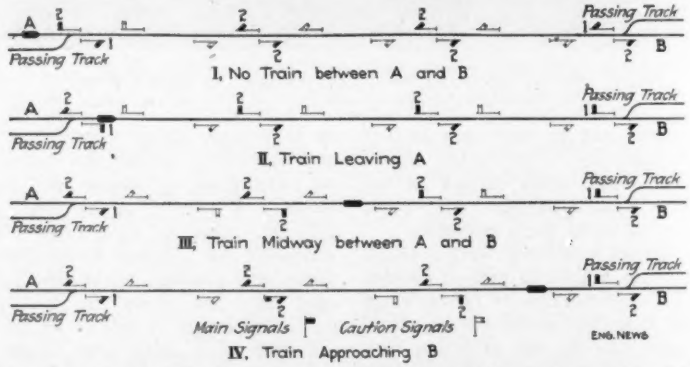


Fig. 2. New "Absolute-Permissive" System of Block Signaling for Single Track; Chicago, Burlington & Quincy R.R.

*Signal Engineer, Chicago, Burlington & Quincy R.R., Chicago.

that directors of railways have sometimes been made to feel that they have spent large sums of money to obtain insurance that does not insure.

Automatic Block-signal System of the C., B. & Q. R.R.

Within the past twelve months a system of automatic block-signalling for single track has been devised which for want of a better name is known as the "absolute-permissive" (A-P) system, so called because it absolutely blocks opposing trains from one passing siding to the next, while it permits following movements close enough together to prevent a congestion of traffic. The development of this system is of too recent a date to have permitted of sufficient service tests to fully demonstrate its efficiency. But the Chicago, Burlington & Quincy R.R. put 45 miles of it in service in December,

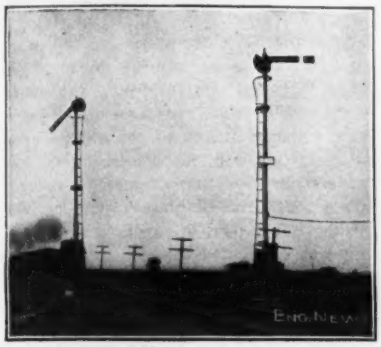


Fig. 4. Intermediate Home Signals (Between Passing Tracks)

(The one at the right is at "stop," to protect the rear of the train which has just passed. At the left is the back of the signal for opposing trains).

1911, and the performance so far has encouraged the operating officers to believe that it will enable them to dispense with some of the cumbersome flagging rules with which single-track automatic operation has heretofore been safeguarded, and that it will eventually be developed to a point where (as under the staff block system on English railways) trains may be run without meeting orders and will pass when they meet, as that will always be at a passing siding.

The circuits used on the Chicago, Burlington & Quincy R.R. were designed by two of its employees, but one of the large signal companies has a circuit plan designed to the same end. This latter, as far as I am aware at this time, has not yet been put in actual service, though one or two installations are now under way.

Reference to the diagrams Figs. 1 and 2, herewith, will show the difference between the single-track system as used heretofore and the A-P system. In the former (Fig. 1), each train only holds at "stop" the signal at the opposite end of the block it enters. With the latter (Fig. 2), as soon as the train leaves the vicinity

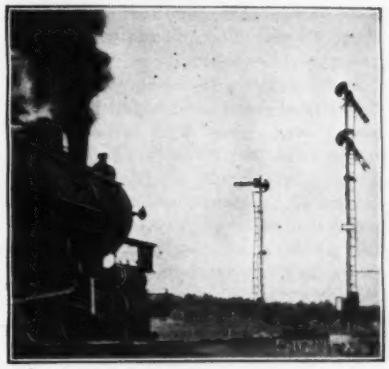


Fig. 3. Train Entering Station Limits

(At the right are both governing signals at "clear." At the left is the opposing stop-and-stay signal at "stop.")

of one passing track *A* it sets all the opposing signals between "A" and the next passing "B" at "stop." But as the train advances, the signals for following movements clear up behind it, as it leaves each block, thus allowing as many trains to follow each other as there are blocks between the two passing sidings.

The signals at each passing track, marked 1,1, on the diagrams, are what are technically known as "stop-and-stay" signals. That is, if the signal is in the "stop" position a train is not allowed to pass it unless it receives an order to do so from the dispatcher (this in case the signal is out of order). Fig. 3 shows one of these signals (at the left) at the "stop" position against trains in the opposing direction to the train shown. If "A" and "B" are open stations, such orders (or clearances as they are generally called) may be had through the operator on duty; where they are closed, telephone communication is provided with

Fig. 6. Signals at Station Limits with No Trains in Either Block (All Indicating "Clear")

(The signal at the left is the stop-and-stay signal for opposing trains).

the dispatcher, so that conductors and enginemen may get the clearance from him. The intermediate signals shown as 2, 2, 2, are "stop-and-proceed" signals. That is, with a signal displayed in the "stop" position, a train must be brought to a full stop before passing it; after which it may proceed (having first sent out a flagman in advance) until it meets an obstruction or arrives at a clear signal.

It is this latter stop-and-proceed rule (requiring flagging), which was inherited from the original system, that it is now thought can safely be dispensed with. In its place is substituted the same rule used for years on double track; that is, after stopping, proceed at once cautiously to the next clear signal. This would at once eliminate the most objectionable feature

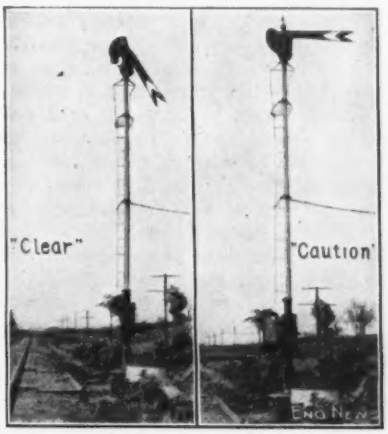


Fig. 5. Caution Signal for Intermediate Home Signal

(Shown in its two positions).

of the single-track automatic system, because this flagging through blocks two or three miles long is a slow and laborious process and one which it is hard to make brakemen follow out. It must be lived up to, however, if safety is to be insured, because there is no way of telling whether the signal is at stop for a train approaching in the opposite direction or not; and if it is at "stop" for that reason it would be manifestly unsafe to pass the signal except under flag protection.

With the A-P system, on the other hand, a train arriving at "A," and finding its signal clear knows that as soon as it has arrived within 300 or 400 ft. of this signal it has set the opposing signal at "B" at "stop," and that no train dare pass that signal without a clearance, which the dispatcher will certainly not give as long as he knows by the report from the last open station that this train leaving "A" is in the vicinity. If he should give it, however, both trains will be stopped by one or the other of the intermediate signals; and as they will then proceed cautiously, the chances of their butting into each other are very remote.

Fig. 4 shows two of these signals, the one on the right being at the "stop" position to protect the rear of the train which has just passed. The one at the left, of course, faces the opposite direction and controls opposing trains.

Caution signals are provided also, as shown in the diagrams. Where the three-position signal (either upper or lower quadrant) is used, each signal stands at caution while the signal next beyond it in the direction toward which a train is moving stands at stop. The standard of the Chicago, Burlington & Quincy R.R., like that of the Harriman Lines, is a lower-quadrant, two-position signal; caution signals being given by blades of shape and color different from those of the stop signals.

On the C., B. & Q. R.R. installation of the A-P system, therefore, each stop or home signal has a separate caution signal of its own placed approximately 2500 ft. from the stop signal. This is this company's practice, as it is considered much more in the line of good signaling to give the caution signal at the time it is to be acted on than to give it a couple of miles (often 15 minutes) before that time, which is the usual practice where three-position signals are in use. This is a mere detail of construction and in no way affects the principle of the A-P system. It will be seen by the diagram that where a signal is in the "clear" position while the next one is at "stop," the caution signal placed between the two shows "caution" as long as the home signal shows "stop." Fig. 5 shows one of these caution signals in its two positions. At the base of the post is the relay box, which is open in the right-hand view.

Fig. 6 shows the signals at the entrance to station limits, with no train in either block. Of the two signals on the right-hand post, the top arm is the advance or home signal, and the lower fish-tail arm is the caution signal for the advance signal at the other end of the station limits. With a train approaching these signals from the block in the foreground, the stop-and-stay signal on the post at the left would be at "stop" (as in Fig. 3), so as to hold any train from the opposite direction.

A fair performance for automatic block signals is 18,000 movements to one false-stop failure. At this rate, in an installation like that shown in the diagram, with four signals between each pair of passing tracks, 4500 trains would pass before one of them was stopped by a false-stop signal, and as only one of the four signals is a stop-and-stay, the dispatcher would be called on for a clearance only once for 18,000 trains. Of course, this is the case with one isolated block, and on a division with 40 such blocks it would occur, somewhere, once for each 450 trains. But with a movement of 20 trains a day that would mean about once in three weeks, which is not a very serious matter.

If the A-P system after a year's trial develops as its friends hope, there is no reason why a good deal of single-track railway may not be operated by automatic block-signals only, and a vast amount of dispatching cut out. It is certain that until single-track automatic signals are developed to produce some such result, they will never be greatly in favor with operating officers.

The signals in this installation are the ordinary type of 10-volt direct-current motor-operated semaphores; they are operated through ordinary 4-ohm track relays and 500-ohm line relays, which type of material can be furnished by any of the large signal companies. The Chicago, Burlington & Quincy R.R. furnishes the labor for all its installations, and usually buys its material on competitive bids from any of the manufacturers who furnish it. Material furnished by any one of the large companies can be applied to such an installation, as there is nothing peculiar in any of the material used in this method of signaling, it being the same as is used for any other type of automatic block signals.

Rail-Wear and Corrosion in the Simplon Tunnel

During the last two years the subject of corrosion and wear of rails in the Simplon tunnel has been under investigation by the engineering department of the Swiss Federal Railways. In 1909 remarkably heavy rail-wear was reported from the tunnel; a maximum wear of nearly ⅛ in. per year was found, and this under a traffic far from "heavy," certainly much lighter than the maximum which the line might ultimately be expected to carry. The tunnel is the longest in the world, being 12¼ miles long; it has maximum gradients of 0.7%. From the beginning it was operated by electric traction (alternating current, with rail return). Under these circumstances it differs sufficiently from other tunnels to justify doubts as to whether the conditions in it as related to corrosion are the same as in other tunnels, i.e., whether the high rate of rail wear might be due to special conditions. The subject was therefore put under investigation. A. Dänzer-Ischer reports the results in the *Schweizerische Bauzeitung* of Apr. 13 and 20, 1912. The following notes are abstracted from his article.

Observed Wear and Corrosion

Systematic measurements confirmed the reports of very rapid wear of the rail head. The wear actually found averaged as follows:

RAILHEAD WEAR, MILLIMETERS DEPTH

	Jan. 1, 1906, to June 30, 1910	June 30, 1910, to Feb. 28, 1911
North half of tunnel	2.678	0.413
South half of tunnel	4.644	0.880
Entire tunnel	3.661	0.419

Reducing these figures to mean annual wear gives:

MEAN ANNUAL RAIL-WEAR, MILLIMETERS DEPTH

	Jan. 1 1906, to June 30, 1910	June 30, 1910, to Feb. 28, 1911
North half of tunnel	0.195	0.630
South half of tunnel	1.035	0.720
Entire tunnel	0.814	0.674

In addition, heavy corrosion of the steel tie-plates was observed. Some of these showed typical exfoliations of rust, while others showed pitting. The former appeared where the roadbed was moist but not wet, while the pitting corrosion occurred where the roadbed was very wet, water dripping or standing. Where pitting corrosion occurred the upper surface of the tie-plate, under the rail base, often showed a hammering down of the ridges between pits, evidently the effect of the traffic load. In some cases there were signs of fusion of the sharp edges of the pits, doubtless chargeable to the reduced cross-section of metallic contact between rail and tie-plates where current left the rail to pass to earth.

It was concluded that the two kinds of corrosion differed only by virtue of the washing-out effect of water standing in or around the tie-plate, this water being churned in and out by the movement of the rail in the plate under trains and thereby scouring out the looser particles of rust and producing the clean pitted appearance.

Points of Maximum Attack

The rail-wear at the maximum point was three to four times as high as the average, exceeding 10 mm. at six localities and up to 14½ mm. at one point (for the five-year period). These points of maximum always coincided with points where water was dripping into the tunnel through the roof. No conditions were noted which would lead to any other conclusion than that the extreme rate of rail-wear at these points was due to the water.

Composition of Water

Analyses of the tunnel water were made on samples taken from nine points where heavy drip occurred; six of these were points of abnormally high wear, while at the other three points the wear was normal or but slightly in excess. The results were not sufficient to account for the excessive corrosion or rail-wear. The samples analyzed showed a considerable range in total solids, in alkalinity, in amount of sulphates, etc., but none of these items was grouped in a way to account for the corrosion. For

example, of two samples showing high sulphates, one was from a location with low rate of corrosion while the other corresponded to a very high rate of corrosion.

Effect of Electric Current

The rail-return current was measured in both rails at frequent intervals along the length of the tunnel. It was found to be a maximum at both ends of the tunnel and to have a fairly uniform value throughout the larger part of the tunnel's length. The average of about 100 amperes (sum of both rails) increased to about 200 amperes at either end of the tunnel.

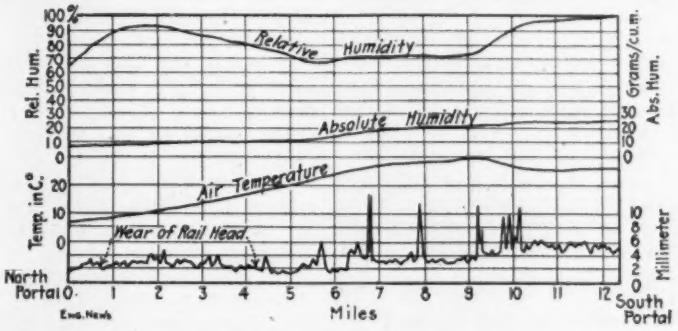
However, the distribution of rail-wear along the tunnel, as plotted from measurements made at short distances apart, was quite dissimilar to the distribution of the rail return current. This fact at once indicated that the corrosion and wear phenomena are independent of the current. Further, as the current is alternating, with a periodicity of 15.7 cycles per second, it was considered doubtful from the beginning whether any connection would be found between the corrosion and the electric current.

To settle the matter conclusively, a single rail-length (in one rail only) was insulated both from ground and from the adjoining rail-lengths by treated wooden plates, and for further protection against the passage of current through this rail-length it was shunted by a copper bond. Measurements were then made through a period of a year of the wear of this rail and of the adjoining rails for some distance either side, measurements being made every two meters. The results, plotted in such a way as to show the progressive corrosion, indicated no difference whatever between the insulated rail and the adjoining rails through which current was passing. This experiment, then, justified the conclusion that the electric current in the rail has no relation to the observed corrosion.

Effect of Humidity and Temperature

Measurements of moisture and temperature of the air in the tunnel were made at a large number of points on various dates. Plotting these values on a diagram representing the length of the tunnel, the curves of absolute humidity were found to show a marked parallelism to the curves of rail wear.

The curves of relative humidity showed a greater variation and irregularity than either the temperature or the absolute-humidity curves. This is due in part to the method of ventilation, and in part to the variations of temperature along the tunnel. The tunnel is ventilated by blowing in air at the north (Brigue) end, at the rate of about 200,000 cu.ft. per second, the air escaping at the south (Iselle) end. Before the air has traversed more than one-fifth of the tunnel's length from the north portal, it is nearly saturated, but toward the middle of the tunnel its temperature has risen sufficiently to make its relative humidity lower (about 60 to 70%). Shortly beyond the middle a region of considerable water-inflow and of maximum tunnel temperature is reached, and in consequence the air in the southerly one-fifth of the tunnel's length is practically at saturation.



Simplon Tunnel; Diagram of Rail-Wear, Air Temperature, Relative Humidity and Absolute Humidity

The illustration reproduced herewith (redrawn from Mr. Dänzer-Ischer's article) shows the parallelism between absolute moisture, temperature of air in the tunnel, and rail wear, in striking manner. It points directly to the conclusion that, all other factors of possible influence on corrosion having been eliminated, the effect observed must be due to the moisture of the tunnel air and the prevailing temperature, in combination. The author refers to the increased activity of corrosion as the temperature increases (maximum at about 150° F.), and considers that this plays a part in the present case.

The connection between humidity, temperature and corrosion of metals in the tunnel is further brought out by the peculiarity of the corrosion figures given earlier in this article. The tabulated figures show that in the earlier period of the tunnel's operation, from 1906 to 1910, the yearly rail-wear was greater than in the following period, although the traffic was less in the early years. It happens that from the time the tunnel was opened to traffic (1906) until August, 1908, a water-spray air-cooling plant was in operation at a point about the middle of the tunnel's length. This device failed to prove effective, and further gave much trouble by producing fog. The additional moisture which it sent into the tunnel necessitated the plentiful use of sand by trains pulling up the 0.7% grade. It might, therefore, be expected that during the period of operation of this plant greater rail-wear, both as pure wear and as abrasion following upon corrosion of the rail-head, would be found.

Rail-wear in Steam-operated Tunnels

To throw further light on the subject, comparison was made with rail-wear in the St. Gotthard tunnel and the Hauenstein tunnel, both of which are operated by steam.

In the St. Gotthard, the distribution of rail-wear along the length of the tunnel again showed a very marked parallelism to the temperature curve. The average rate of rail-wear was found to be somewhat less than twice as great as that in the Simplon, although the traffic is considerably over twice as great and the tunnel contains large amounts of smoke at all times (in spite of the Saccardo ventilating system). The circumstances make it appear unlikely that either smoke or volume of traffic is to be regarded as a guiding factor in determining the amount of corrosion of metal in this tunnel.

A similar result was derived from the Hauenstein tunnel (2.63% gradient). Here, with a distribution of wear quite different from that observed in the Simplon, the wear curve and the moisture curve show a strong similarity, whereas no parallelism can be traced between these curves and the smoke distribution. In both the St. Gotthard and the Hauenstein, the relative humidity is practically 100% in the entire length of the tunnel except immediately at the portals.

The Location of the Garden of Eden is claimed by Sir William Willcocks, M. Inst. C. E., Adviser to Public Works (Turkey), of Cairo, Egypt, to have been on the Upper Euphrates River, between Anak and Hitt. It is part of the proposed irrigation scheme in the valleys of the Tigris and Euphrates Rivers to restore the reputed residence of Adam and Eve to its original luxuriance. Sir William stated at a recent meeting of the Royal Geographical Society in London that when the proposed irrigation works were completed and the Euphrates-Tigris delta reclaimed, this ancient seat of civilization would become as prosperous as the delta of the Nile, in Egypt. Sir William has discovered a depression 500 square miles in extent, which he believes can be used as a reservoir basin in controlling the Euphrates, and which he thinks was used for that purpose by the ancients. The theory is that great floods changed the course of the river and destroyed the ancient irrigation works, and for many centuries the region has been a desert.

Wind Pressure on Inclined Roofs

Tests have been made at Reno, Nev., using a testing shed with a roof area of 60 sq. ft. on each slope. The results indicate that the pressure varies directly with the wind velocity. Previous experiments, for the most part with small models, have given the pressure as varying with the square of the velocity.

The Reno tests, if accepted as conclusive, make the downward pressure of the wind on roofs of less importance than the upward lift or suction.

The pressure of the wind against roofs and walls is a matter of importance concerning which very little is definitely known. Many have tried to determine experimentally the amount of this pressure and the way in which it varies with the wind velocity. In most cases, however, the experiments have been made with surfaces of comparatively small area and often with artificially produced air currents. Therefore, the results are not necessarily applicable to full sized roofs and walls under actual conditions.

Experiments have been recently made at Reno, Nev., under conditions which perhaps more nearly approach the actual. These are described by H. T. Boardman* in a paper published in the April, 1912, *Journal* of the Western Society of Engineers.

Mr. Boardman's experiments were made with the test house shown in Fig. 1. Measurements were made of the wind pressure on the roof of this house and simultaneous anemometer readings were taken at a distance of about 20 ft. to windward.

The house was situated on a slight rise of ground with free exposure to the prevailing (westerly) wind. The nearest building to windward was at a distance of over 400 ft. The test house was half-way between two buildings, lying 125 ft. away to the north and south, respectively.

FIG. 1. WIND PRESSURE TEST HOUSE AT RENO, NEV.

(The man at the left is holding the anemometer for wind velocity measurement.)

The construction of the test house is shown in Figs. 1 and 2. The chief dimensions are shown in Fig. 2 with the exception of the length in a direction perpendicular to the plane of the picture, which was 10 ft. Apart from its small size, it differed from an ordinary building chiefly in being open at the rear and in having no projecting eaves. The roof surfaces were covered with prepared waterproof roofing and the gable ends were closed with galvanized iron sheets, so hung as not to interfere with the motion of the roof up or down except by friction in sliding one over the other. The range of inclination possible was from 15° to 70° with the horizontal.

*Professor of Civil Engineering, University of Nevada, Reno, Nev.

The end walls were extended back somewhat beyond the furthest position of the rear edge of the roof. The openings along the windward eaves and at the ridge were covered by small canvas curtains weighted with iron rods at the lower edge. The house was so mounted that it could be revolved through an arc of about 60°, so as to face the wind, the center of rotation being at the center post of the windward face.

The method of measuring the wind pressure against the windward slope of the roof was by means of a lever and a spring dynamometer, as indicated in Fig. 2. In computing the pressure on the roof in pounds per square foot from the dynamometer reading it was assumed that the pressure was uniformly distributed over the 60 sq.ft. of roof area. No account was taken of the pressure (positive or negative) on the leeward slope of the roof.

The anemometer readings from which the wind velocity was computed were taken by a man standing in the position shown in Fig. 1. The instrument was held in the hand of the observer at a height differing but little from that of the center of the roof surface. The anemometer was fitted with a stop lever by means of which the revolving pointers on the dial could be thrown out or into action, but the vanes remained in motion without reference to whether the pointers were moving or not.

The method of taking observations was as follows: One person held the anemometer, while the other remained inside the house watching the dynamometer and holding a stop watch. When the inside man saw from the action of the dynamometer that it was a good time for a test, he shouted a signal to the outside man, at the same time starting his stop watch. He kept his eyes on the dynamometer pointer and when it changed its position materially he shouted a stop signal to the outside man, at the same time stopping his watch. He then recorded in a note book the estimated reading of the dynamometer, the time of test, and the number of feet movement of wind as indicated by the anemometer for the period of the test, the latter being called to him by the outside man.

All the high velocities came in gusts lasting from a fraction of a second to 10 seconds, but very few recorded tests were for less than two or three seconds. Some few good tests were made for between one and two seconds. Following the tests the anemometer was calibrated by whirling it about a vertical axis in a circle whose circumference was 50 ft. The anemometer was found to indicate too low velocities below 12.8 ft. per second. (about nine miles per hour) and too high velocities above that speed. The correction factor varied from 1.03 at five miles per hour to 0.995 at about 50 miles per hour.

The results of the test are shown graphically in Fig. 3. Both the results of Mr. Boardman's test and those of previous tests made under his direction by two students, J. E. Sears and J. A. Miller, are included.

For comparison, curves are also given in the diagram corresponding to the results of tests made in England by Thomas

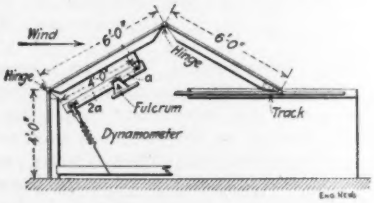


FIG. 2. DIAGRAM SHOWING DIMENSIONS AND MECHANISM OF TEST HOUSE

E. Stanton, described in 1907, in Vol. CLXXI of the *Proceedings* of the Institution of Civil Engineers in an article entitled "Experiments on Wind Pressure." Mr. Stanton found that the pressure was proportional to the square of the velocity of the wind. Mr. Boardman's tests, on the other hand, indicate a straight-line formula for the relation between pressure and velocity. This is especially clear with inclinations of 40° and 70° for which velocities above 40 miles were tested.

In commenting on the great difference between his results and those of Mr. Stanton, Mr. Boardman states that Mr. Stanton's model roof was mounted 50 ft. above the ground, while Mr. Boardman's was connected to the ground by a 4-ft. wall. Mr. Boardman suggests that with free passage for the air under the model roof, as in the case of Mr. Stanton's experiment, there would be less obstruc-

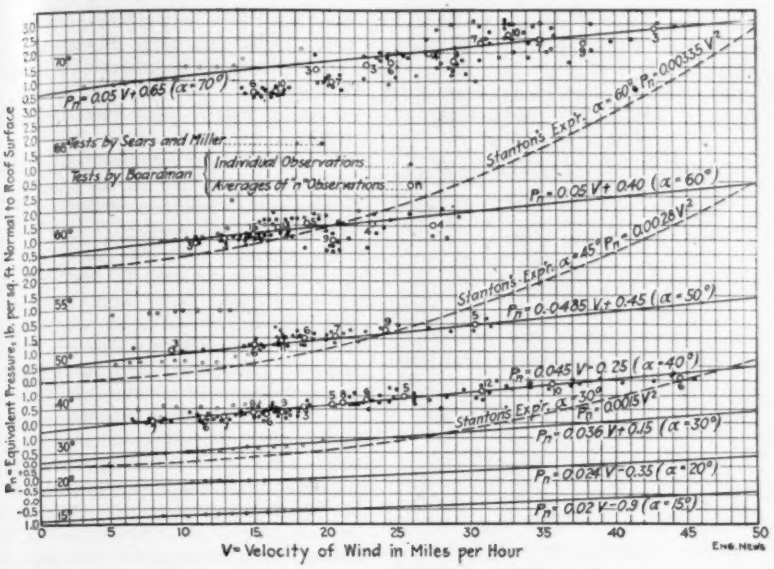

Pn = Equivalent Pressure, lb. per sq. ft. Normal to Roof Surface
V = Velocity of Wind in Miles per Hour
Tests by Sears and Miller
Tests by Boardman
Individual Observations
Averages of n Observations
Pn = 0.05 V + 0.65 (α = 70°)
Stanton's Expr. α = 60° Pn = 0.0035 V²
Pn = 0.05 V + 0.40 (α = 60°)
Stanton's Expr. α = 45° Pn = 0.0028 V²
Pn = 0.0435 V + 0.45 (α = 50°)
Pn = 0.045 V + 0.25 (α = 40°)
Stanton's Expr. α = 30° Pn = 0.0015 V²
Pn = 0.036 V + 0.15 (α = 30°)
Pn = 0.024 V - 0.35 (α = 20°)
Pn = 0.02 V - 0.9 (α = 15°)
Eng. News

FIG. 3. CURVES SHOWING RESULTS OF BOARDMAN'S WIND PRESSURE TESTS
(Curves of Stanton's experiments shown for comparison.)

tion of the air, less deflection of the main air current upward and consequently greater pressure on the roof than in the case where it was connected to the ground by a continuous wall.

The negative pressures obtained for low velocities with low inclination of the roof are explained by Mr. Boardman as follows: The wind being deflected upward by the windward surface of the roof tends to draw with it, and so rarify, the air over the leeward surface, thus permitting the air within the building to press upward with greater force than the air on top of the leeward surface presses down. This reasoning, he stated, was supported by the behavior of the canvas curtain covering the crack at the ridge between the windward and leeward slope. Always in a high wind with the roof at a low inclination this curtain was bulged upward.

The curves shown in Fig. 4, giving the relation between the normal pressure and the inclination of the roof for different velocities, were obtained by computing the pressure for velocities of 10, 30, 50 and 100 miles per hour from the straight-line formulas shown in Fig. 3 for the different inclinations from 15° to 70°. The writer confesses that in selecting the straight lines taken as averages in Fig. 3, he was somewhat influenced by the way the points obtained from them plotted on the diagram of Fig. 4. The writer notes that the values of pressure for 40° inclination in every case fall below the curves, but he is unable to offer an explanation for this discrepancy.

The equations shown in Fig. 4 for the curves for 100 miles per hour were obtained by the usual logarithmic method, assuming that the curves were parabolas with the vertex on the vertical line through 90° inclination. The upper curve for velocities of 100 miles per hour was obtained by multiplying the second member of the equation by 1.18, the author assuming that since the atmospheric pressure at sea level is about 18% greater than at Reno, it was reasonable to suppose that the wind pressure at sea level would be about 18% greater.

DISCUSSION

In the discussion of Mr. Boardman's paper before the Western Society of Engineers, criticism was made of the failure to take account of the pressure on the lee slope and of the assumption of uniform pressure on the windward slope. It was pointed out that Irminger's experiments (ENG. NEWS, Feb. 14, 1895, p. 109) showed that the center of pressure on the windward slope would be below the middle of the slope, and that the pressure on the leeward slope would be an outward pressure or suction.

To determine the error due to neglecting the pressure on the lee slope of the roof, consider the diagram (Fig. 5) showing the forces acting. In the lower part of the diagram, the two leaves of the roof are shown separately in order that the forces at the ridge hinge may be clearly indicated.

The forces V and H at the hinge are due to the force P on the lee slope and their value can be obtained, in terms of P, taking moments about the roller at the leeward eaves and again about the ridge. Then by taking moments about the hinge at the windward eaves, we obtain an equation between H and V, S and W. This equation, with H and V expressed in terms of P, can be reduced to the following:

$$S = \frac{3}{2} W (1 - m) + \frac{3}{2} P (\sin^2\alpha - \cos^2\alpha + k)$$

in which S is the dynamometer reading (corrected for leverage), W is the resultant pressure on the windward slope and P is the resultant suction on the leeward slope. The significance of m, k and α is indicated in the diagram.

In this equation, it should be noted that W enters with the coefficient $\frac{3}{2}(1-m)$ which is unity only when $m = \frac{1}{3}$; and that P enters with a coefficient that is not zero. Therefore, S would be equal to W only when $m = \frac{1}{3}$ and $P = 0$.

As a matter of fact, m has probably a value more nearly equal to $\frac{2}{3}$ than to $\frac{1}{3}$. In the case of the pressure P, however, it was pointed out by Prof. O. H. Basquin, in the discussion of the paper, that the resultant force on the lee slope was doubtless quite small for the reason that the rear of the test house was open,

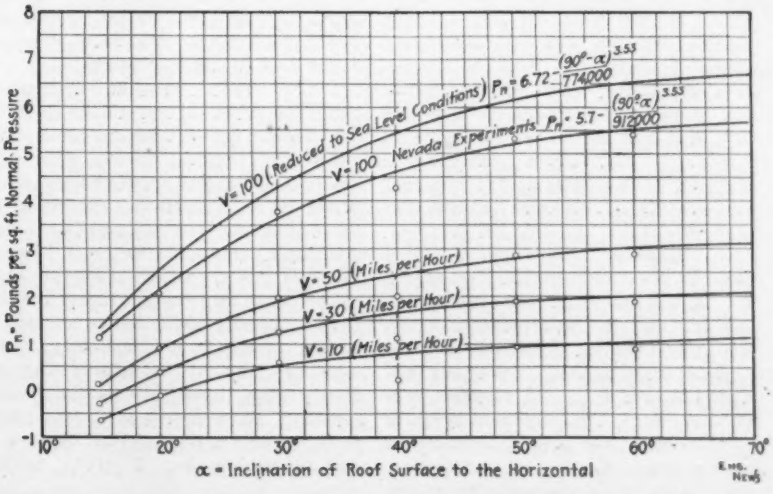

Pn = Pounds per sq. ft. Normal Pressure
α = Inclination of Roof Surface to the Horizontal
V = 100 (Reduced to Sea Level Conditions) Pn = 6.72 - (90°-α)^3.53 / 774000
V = 100 Nevada Experiments Pn = 5.7 - (90°-α)^3.53 / 912000
V = 50 (Miles per Hour)
V = 30 (Miles per Hour)
V = 10 (Miles per Hour)
Eng. News

FIG. 4. CURVES SHOWING RELATION BETWEEN WIND PRESSURE AND SLOPE OF ROOF FOR DIFFERENT WIND VELOCITIES
(These curves were derived from those shown in Fig. 3.)

allowing free expansion of the air in the house.

Measurements of the air pressure inside the test house were subsequently made by Mr. Boardman with an aneroid barometer. He found the inside pressure to be from 0.02 to 0.04 in. of mercury lower than the outside pressure, with wind velocities of 25 to 41 miles per hour. This was with the roof at less than 15° inclination—which supposedly would give the maximum suction effect.

It was further shown by Mr. Boardman that the value of the coefficient of P, in the equation for S already given, had a value of zero for 30° inclination of the roof and a negative value for inclinations less than 30°.

The reduced pressure inside the test-house, due to its being open behind, would increase the pressure on the wind-

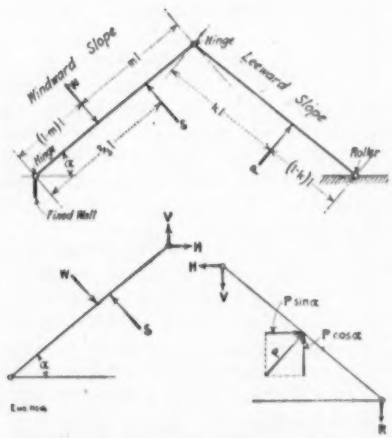


FIG. 5. DIAGRAM FOR ANALYSIS OF STRESSES ON TEST-HOUSE ROOF

ward slope above what would normally be found in a closed building. This is important in view of the fact that these tests already indicate very much lower values for the wind pressure at high velocities than are commonly used in the design of structures. Hutton's formula for wind pressure, which has been widely used, gives 18 lb. per sq.ft. for a roof of 60 ft. span and 15 ft. rise. According to Boardman's experiments, assuming a maximum wind velocity of 100 miles per hour (see Fig. 4) this value becomes 3.75 lb. per sq.ft.

Mr. Boardman has also computed values of the normal pressure on such a roof, as determined by his experiments, assuming that the unit pressure varies from a maximum at the windward eaves to zero at the ridge, that is, with the center of pressure at ⅓ the distance from eaves to ridge. The maximum pressure at the eaves of the roof in question, as thus computed, was 11¼ lb. per sq.ft.

In closing the discussion, the author expressed the opinion that his tests, taken in connection with the experiments of Stanton, Irminger and others, show that the lifting force of the wind should be considered of equal or perhaps greater importance in roof design than the downward force, therefore demanding ample provision in the way of anchorage.

Turbine Driven Centrifugal Pumps for Water Works Service*

BY WALTER O. BEYER†

It is only recently that centrifugal pumps have received the serious consideration of water-works engineers, although their economy and efficiency have long since been demonstrated for supplying water in large quantities to industrial plants. It is our purpose here to show that the combined fixed charges and operating costs of the rotary unit compare favorably with those of the high-duty vertical triple-expansion reciprocating pumping engines, where the price of coal is not excessive.

The high duty shown by reciprocating engines in water-works service, involving the pumping of large quantities of water against a constant head, without any great variation in rate, has long and justly been regarded as a supreme achievement. Due to the direct connection of the pump and engine cylinders and to the high efficiency realized in the unit when the proper attention is paid to its valves and packings, the triple-expansion reciprocating pumping engine has been able to develop duties that are unapproachable by rotary units consisting of turbines and centrifugal pumps. However, a careful comparison of the total costs of pumping will show that the balance may be entirely reversed when fuel costs do not exceed a certain price per ton. That is, the high first cost of the reciprocating unit together with the cost of the foundation required, introduce annual charges for interest, upkeep and depreciation which more than offset the lower duty of the turbine unit.

Of the several types of pumping engines the following are chiefly used for water-works service; low-duty compound condensing engines, costing with foundations, piping and appurtenances about $2300 per million gallons capacity per 24 hours; low-duty triple-expansion condensing horizontal engines, costing about $2800 per million gallons capacity; cross-compound condensing horizontal flywheel engines, costing about $3300 per million gallons capacity; and high-duty triple-expansion vertical condensing engines, costing about $4800 per million gallons capacity. These figures are from a paper presented before the American Society of Civil Engineers, May 17, 1911, by the late Chas. A. Hague. Since this paper selected the high-duty triple-expansion vertical engine as the only one to be considered in most cases, it is with this type of engine that we shall make our comparison.

The prices for pumping units given below are to the best of our knowledge, accurate and include condensers, piping and foundations complete.

No account has been taken of the greater space required in the buildings for reciprocating units—as a unit volume cost must be assumed which would agree with only one architectural design. Similarly no account has been taken of the greater volume of building required for the larger boiler installation necessary to supply the turbine units, for the majority of existing plants usually have their building proportions determined and a saving could not be made in either room without special complications of no account in this discussion. However, the difference in cost of foundations has been taken into account, because this is an addition in existing buildings and can be easily computed.

In a new station the turbine should be credited with any saving in floor space, buildings, etc., which it may effect as compared with the reciprocating engine, and the reciprocating engine should be credited with the saving effected in the boiler rooms.

In a comparison of this kind, certain assumptions must necessarily be made. We have tried to eliminate as far as possible arbitrary assumptions, and all figures of first cost of apparatus have been taken from, or estimated from recent bids on the two types of machinery under consideration. The first cost per boiler horsepower, for the turbine-driven centrifugal unit we have taken to be $30 complete, with piping, chimney, stokers, etc. (The use of a lower figure would favor the turbine-driven pump as compared with the high-duty engine, but we believe with everything taken into consideration, this will prove to be an average figure.) We have assumed the following annual charges against pumping machinery:

Interest	5%
Depreciation	3%
Repairs and supplies	2%
Total	10%

We have also assumed the following annual charges against the boiler equipment:

Interest	5%
Depreciation	5%
Repairs and supplies	5%
Labor on maintenance	2%
Total	17%

It will be noted in the above that an annual depreciation of 3% has been taken on the first cost of both the crank and flywheel and turbine-driven unit, equivalent to a life of 33⅓ years. We have chosen this method rather than one

*Condensed from a paper read before the American Water Works Association, Louisville, Ky., June, 1912.

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in which the capital charges are figured on a constantly decreasing book value for the pumping machinery and boilers, in order to avoid a complicated method of accounting.

For the reason that fewer data are available on the life of turbine-driven units, than on crank and flywheel units, it is possible some objection may be made to this assumption of a life of 33⅓ years for each machine. However, as in neither case the question of obsolescence has been taken into account, we believe the assumption a fair one. Viewed in the light of possible future development, it would seem that a longer life should be accorded to the turbine-driven unit than to the crank and flywheel unit, as a very thorough canvass of the whole field of pumping equipment does not bring to light any mechanical apparatus which is being developed to compete with the turbine-driven machinery to the same extent as the turbine-driven machinery is being developed to compete with the crank and flywheel machinery.

It further appears that the steam turbine has reached a stage of development such that improvements will appear only as refinements of type, and steam economies can only possibly be reduced sufficiently to render obsolete the present good designs, by better theoretical design and by better steam conditions. The use of high steam pressures and superheat may be expected to gradually obtain further favor in this country as in European practice, where 250° F. superheat and 200 lb. steam pressure are not unusual. This, however, entails practically no change in turbines as constructed for present steam conditions.

Fuel costs are based on a boiler efficiency of 65%, heat content of 13,000 B.t.u. per pound of coal and 24 hours per day operation. The duties given are on a basis of 150 lb. steam pressure with no superheat. Three examples are taken, based on coal at $2, $3 and $4 per ton. Where coal can be obtained cheaper than $2 per ton the advantages of the turbine-driven pump are more clearly marked.

TABULATION "A"

8,000,000 gal. per day.	350 ft. head	491 water hp.
Item	Vertical crank and flywheel, triple expansion, 150,000,000 duty, 3–125 hp. boilers	Steam turbine, centrifugal, 105,000,000 duty, 3–175 hp. boilers
Cost of pumping unit	$72,000	$16,000
Int. depreciation, etc., etc., 10%	7,200	1,600
Cost boilers	11,250	15,750
Int. dep., etc., 17%	1,915	2,680
Labor, 3 shifts, engines	2,700	2,700
boilers	1,800	1,800
Total int., dep., etc., and labor	13,615	8,780
Fuel cost, $2 per ton	7,467	10,700
Fuel cost, $3 per ton	11,129	16,100
Fuel cost, $4 per ton	14,934	21,400
Total annual cost, $2 per ton coal	21,082	19,480
Total annual cost, $3 per ton coal	27,744	24,880
Total annual cost, $4 per ton coal	28,549	30,180

TABULATION "B"

8,000,000 gal. per day.	280 ft. head	981 water hp.
Item	Vertical crank and flywheel, triple expansion, 165,000,000 duty, 3–225 hp. boilers	Steam turbine, centrifugal, 120,000,000 duty, 3–300 hp. boilers
Cost pumping unit	$120,000	$26,000
Int., dep., etc., 10%	12,000	2,600
Cost boilers	20,250	27,000
Int. depreciation, etc., 17%	3,440	4,580
Labor, 3 shifts, engines	2,700	2,700
Labor, 3 shifts, boilers	1,800	1,800
Total int., dep., etc., and labor	19,940	11,690
Fuel cost, $2 coal	13,570	18,630
Fuel cost, $3 coal	20,335	27,945
Fuel cost, $4 coal	27,140	37,260
Total annual cost, $2 coal	33,510	30,320
Total annual cost, $3 coal	40,275	39,635
Total annual cost, $4 coal	47,080	48,950

TABULATION "C"

40,000,000 gal. per day.	300 ft. head	2120 water hp.
200 lb. steam pressure.	275° F. superheat	28.5 in. vacuum
Item	Vertical crank and flywheel, triple expansion, 223,000,000 duty, 3–350 hp. boilers	Steam turbine, centrifugal, 193,000,000 duty, 3–400 hp. boilers
Cost pump	$210,000	$55,000
Int. dep., etc., 10%	21,000	5,500
Cost, boilers	31,500	36,000
Int. dep., etc., 17%	5,360	6,100
Labor, 3 shifts, engines	7,200	7,200
boilers	5,320	5,320
Total int., dep., etc., and labor	39,480	24,120
Fuel cost, $2 coal	23,265	26,800
Fuel cost, $3 coal	34,897	40,200
Fuel cost, $4 coal	46,330	53,600
Total annual costs, $2 coal	62,475	50,920
Total annual costs, $3 coal	74,377	64,320
Total annual costs, $4 coal	85,810	77,720

It will be noted that the point at which the total annual costs are equal for the eight million gallon crank and flywheel vertical unit, and the eight million gallon turbine centrifugal unit is when coal costs $2.91 per ton. Also for the twenty million gallon vertical crank and flywheel unit, and the twenty million gallon turbine centrifugal unit, the total annual costs will be equal when coal costs $3.25 per ton. Above these prices for coal, the reciprocating unit has the advantage and below these points the rotary unit has the advantage on the basis of these calculations.

We believe that it can be assumed safely that the development of pumping machinery in the future will be along somewhat the same lines as the development of power-producing machinery. At the present time one of the most noticeable features in the development of power machinery is the increasing favor with which larger units are being adopted. In large electric station work five years ago, the ordinary size of unit was from 10,000 to 15,000 kw. Now, not only in European practice, but also in American practice, 25,000 kw. units are being installed in the large stations. There are two reasons for this development, the first being the continual endeavor to obtain better economy, not only in actual steam consumption, but in capital charges, including first cost, buildings, real estate, etc., etc. The second reason for the development along this line comes from the fact that engineers of today seem to have more initiative than formerly and where before the development of a 15,000-kw. turbine would have seemed an impossible task, now the installation of 25,000-kw. turbines is becoming a matter of course.

We have assumed that there will be progress along this line in water-works pumping machinery and that installations of very large units will be made in the future. We have evolved a comparison between two units of the types under consideration, each having a capacity of 40,000,000 gal. per 24 hours, against a total head of 300 ft. This comparison is based on utilizing the greatest range of steam temperature which the best modern practice has established as commercially practicable, and which at the same time is not too intensely theoretical. We refer here to European practice in which steam pressures of 200 lb. 275° superheat, and 28.5 in. vacuum are successfully and commercially utilized.. Especially important in this connection is the item of high vacuum, since in the case of water-works pumping engines large quantities of water are always available for condensing purposes.

Extremely large capacities and high heads present no difficulties, nor disproportionate costs in the construction of steam turbine driven centrifugal pumping units, since it is an inherent characteristic of the centrifugal pump that the larger the capacity, the greater the efficiency for a given head.

There is practically no development necessary on the turbine to take advantage of these conditions, as the turbine of almost exactly the same characteristics that would be necessary for this installation is now in successful operation in hundreds of power-producing plants. We have had to assume no steam consumption, as this is a matter of test, and practically have had to assume no pump efficiencies, as we have taken the minimum which we know can be obtained on this size pump.

Further, the turbine is well adapted to take advantage of the improvement in steam conditions as mentioned above, and reciprocating engines can also be designed as to take advantage of the initial and terminal conditions favoring high economy.

The results of this comparison are shown in table "C." It is apparent from these tables that the point at which the two curves of overall economy of the two units cross, is at a cost of approximately $8.80 per ton for coal.

It would therefore appear that the field of these large capacities at high heads for ordinary coal costs, belongs to the turbine-driven centrifugal pump exclusively.

In conclusion, if the above data are

correct—and it has been our sincere endeavor to present only such figures as are fair for both types of machines—it would seem that the steam turbine centrifugal pumping unit must be conceded a place of primary importance in the field of water-works engineering.

DISCUSSION

In the last 12 years my pumping installations have numbered over one hundred, about 25% of which have been centrifugal; so you will see that I am not wholly opposed to the centrifugal pump. But this paper, if not used intelligently, may work great harm to intending purchasers of pumping machinery. However, this has been guarded against by the author of the paper when he states that the figures given are applicable to uniform load conditions.

The turbo-centrifugal pump is applicable only for use with reservoir service to secure the economies stated, for only with reservoir service can you get uniform load conditions.

Seventy-five per cent. of the water-works with which I come in contact over this country are direct-pressure systems. A large proportion of you come from the Western prairies where there is not a hill high enough on which to build a standpipe even, and you cannot get uniform load conditions, and consequently these figures are not applicable to your service. Suppose we have reservoirs, where we are going to pump out of a lake into a settling basin; would you tell us that that was uniform load condition? Suppose our intake runs out 3½ miles into the lake and the difference between the minimum and maximum head to which we must subject our pumps under the different conditions amounted to 14 ft., the initial head being only 22 ft. That is a variation of 50%, and you have not got uniform load conditions.

How many of you can afford uniform load conditions? The figures in the paper just read are based on load conditions absolutely uniform.

I wish that the author's paper had included pumps down to about 2,000,000 gal. I wish also that it had taken a range down to about 20 ft. head. Then we could have included these filter pumps. There is where we spend our money, raising water 20, 30 or 40 ft. high. There is where the centrifugal pump usually appeals to us to save in first cost; but unfortunately there arises that inevitable variation in our load which must be considered if we are to make an intelligent comparison.

I believe the centrifugal pump has made great advancement. I do not believe it has reached the stage of improvement that the author of this paper expressed his belief that it has; but I believe that it is far more in its infancy than the vertical triple-expansion, crank and flywheel pump. I believe it will make greater strides in the next ten years.

The turbo-centrifugal pump is predicated on a high vacuum. You people who have to lift against from 10 to 50 ft. head and who put in a pump of that kind and try to maintain a 26-in. vacuum, have a loss from leaks six times as great in a small pump as in a large one; that is my experience. When we try in these units to maintain a vacuum of over 26 in., we have to add so many refinements to our condensing apparatus as to materially reduce the efficiency of that type. If the engine is large enough we do not get in the turbo-driven or engine driven centrifugal all the economies that we do with the direct acting or other types of reciprocating pump. I believe there are a great many services for which cntrifugal pumps are the best; but I don't believe they approximate anything like the percentage that the sanguine author of this paper believes in. He advocates large units. He gets away from water-works service and talks about electrical stations where, if you are not using it, the power drops off; but in our water-works engines you know it does not do that. A comparison between the two characters of service, water-works and electrical, is misleading unless it is analyzed.

Again, large units are going contrary to that old proverb, "Don't put all your eggs in one basket." It is not the larger cities that are represented here in this body ordinarily as a majority. In the smaller cities you cannot put in 40,000,000 or 50,000,000 gal. units, because it would be putting all your eggs in one basket. If that unit was down and out you would be in trouble; and if you duplicate such large units you are running up the investment. I always feel that a number of smaller units in water-works practice is preferable to putting in single larger ones. It insures safety, which should be the controlling principle in water-works operation.

Mr. L. E. STROTHMAN, ALLIS-CHALMERS CO., Milwaukee, Wis.: We have often heard it stated by backwoods philosophers that "Figgers don't lie," and that the only reason why they don't lie is because they cannot talk. If the figures used in the tables which have been shown you had the power of speech, I am sure that they would protest violently.

The company with which I am associated builds all types of pumps and pumping engines. Consequently, we are not prejudiced in favor of either the centrifugal or the crank and flywheel type of pumping engine and I am therefore in position to point out the merits or weaknesses of either type without any prejudice.

The cost of pumping engines as given in this paper and in the tables which it contains, is predicated on the approximate figures given by the late Charles A. Hogue, in a paper presented before the American Society of Civil Engineers, in May, 1911. Mr. Chester has brought to your attention the inaccuracy of basing a comparison upon these general figures and I am sure that Mr. Hogue wrote his paper with the idea of giving general information and had no intention of having these figures adopted as representing the actual cost of vertical expansion pumping engines ranging in capacity from 8,000,000 gallons daily to 40,000,000 gallons daily.

I am sure that we would all be pleased if it were possible to prepare accurate data on the cost of vertical triple-expansion pumping engines based merely on the capacity in gallons per twenty-four hours. So far I have seen no such data which are reliable, and believe that the nearest approach is to base the cost of the engine on the water horsepower of the machine and plot curves with the water horsepower as abscissas and the cost per water horsepower as ordinates. By the use of this method it is possible by plotting a great number of curves to arrive at some general idea as to the cost of this type of pumping engine, although this varies from $70 per water horsepower to approximately $230 per water horsepower.

Relative to the question of constant-load conditions which Mr. Chester has also touched upon, I want to repeat what he says, viz., that constant-load conditions mean constant head, constant speed and constant capacity. Up to the present time, the most convenient method of comparing the total operating cost of the two types of machines under discussion has been to assume that both machines run at their point of maximum economy. This is a condition which does not obtain in actual practice and is always unreasonably in favor of the turbine-driven centrifugal pump.

If we expressed the duty which is developed by a vertical triple-expansion pumping engine when running under normal conditions as 100%, we can state the efficiency of the unit when running at half speed in per cent. of the normal. The vertical crank and flywheel pumping engine when running at one-half speed and delivering one-half its rated capacity against the normal head will develop a duty only 5½ or 6% less than that which is developed under normal conditions. The steam turbine-driven centrifugal pump, however, running at half capacity with constant head would be only about 76% of the normal. Taking into account the fact that most pumping engines run at a point somewhere between half and three-fourths capacity, you will see that the vertical crank and flywheel pump has an advantage which is not apparent at the first glance.

Most of the pumping-engine installations in this country today are for pumping water directly into the mains and not into a reservoir. In addition to this, cities that at present have reservoirs are rapidly adopting the direct-pumping system and are no longer using their reservoirs for the purpose of establishing constant-load conditions. The preceding statement is to disprove that the high economies attained by the crank and flywheel pumping engines are due to the constant conditions under which they operate. In any of the direct-pumping systems, the head against which the pumps operate increases in the ratio of the square of the velocity through the distributing system with an increase or decrease in capacity. This condition is very unfavorable for the use of steam-turbine-driven centrifugal pumps.

Referring to the tables which accompany this paper, more especially to table "C," which bases the comparison of annual operating cost on a capacity of 40,000,000 gallons daily against 350-ft. head, I wish to state that the size of a vertical triple-expansion pumping engine is limited by the piston speed at which it operates, and this limitation would preclude the building of a vertical triple-expansion pumping engine of this horsepower. In any form of reciprocating pumping engine in which the piston in the steam cylinder is directly connected to the water plungers, the plunger speed is limited by the rapidity by which the water can follow the plunger. Consequently, with a high-suction lift it is necessary to employ low-piston speeds. The accepted piston speed for pumping engines of this type lies somewhere between 200 and 300 ft. per minute with automatic rubber pump valves, although this speed has been exceeded by the use of mechanically closed annular ring metallic valves, of the Riedler type. The

modern tendency, however, is away from the high piston speed and positively operated water valve on account of the higher expense of producing a pump of this type. We can, therefore, assume that good practice in the construction of vertical triple-expansion pumping engines corresponds with a plunger speed not exceeding 250 ft. per minute. Taking this as a basis and adopting any reasonable steam pressure, say as high as 180 lb. per sq.in., the size of the machine is limited by the size of the low-pressure cylinder and this limits the horsepower to somewhere between 1200 or 1300 indicated horsepower. Even with this horsepower the low-pressure cylinder becomes 110 in. in diameter and with this size of low-pressure cylinder it means that a stroke of 66 or 72 in. is necessary, resulting in a large unwieldy machine which is very expensive to build. I am sure we would not countenance for a moment the building of a vertical shaft crank and flywheel pumping engine for 2100 hp., as indicated in tabulation "C." This last tabulation, therefore, cannot be considered, as it is based upon a size and type of machine which is not practicable to build either in this country or Europe.

I know of no installation that has been made in this country during the last five or six years in which the engineer in charge of the preparation of the specifications did not give the steam turbine-driven centrifugal type of pumping engine very serious consideration. It has been my experience that the men buying this class of machinery know practically as much about it as the builders, and I am satisfied that there have been no serious engineering blunders made in the installation of vertical triple-expansion pumping engines during the past few years.

The 40,000,000-gallon pumping engine described in the third table, known as table "C," is predicated upon the belief that the size of pumping machinery will increase somewhat along the same lines as the increase in size of electric generating units. The Allis-Chalmers Co. is engaged in building large power apparatus and builds probably as many of the large steam turbines for driving generators as any manufacturer in this country. In the generation of power it is possible to employ large units because the power requirements are enormously large compared with the population of the district which is supplied. It is therefore natural that large units should be used, especially as they run at a constant speed and any variation in load is simply a variation in the kilowatt output at this constant speed. This, of course, is not true in any pumping station, as the speed and head both vary considerably during the day and during various parts of the year.

In conclusion, I wish to draw your attention to the greatest injustice in this comparison of the two types of pumps as given in Mr. Beyer's paper, viz., that of the duties which will be developed by the two types of machines. Assuming that the duties as given in tables A, B and C for the steam-turbine-driven centrifugal pumps are correct, I wish to state that under conditions where a steam-turbine-driven centrifugal pump will develop a duty of 105,000,000 ft.-lb., a pump of the vertical triple-expansion type will develop a duty of 175,000,000 instead of 150,000,000 ft.-lb.

Under the same steam conditions, with the centrifugal developing 120,000,000 ft.-lb. duty, a vertical triple-expansion crank and flywheel pumping engine will develop 195,000,000 instead of 165,000,000 ft.-lb.

I have previously stated that the figures in Table "C" should not be given serious consideration, but I wish to point out that the duty of the vertical triple-expansion engine would be practically 300,000,000 ft.-lb. in place of the 223,000,000 as stated.

Mr. EDWARD S. COLE, Hydraulic Engineer, New York, N. Y.: The question of efficiency in a centrifugal pump is of the highest importance, but the purchaser is more interested in maintaining high efficiency throughout the life of the machine than in securing it at the acceptance test.

I have had occasion to make a number of tests of centrifugal pumps in actual operation, such as, for example, the seven 40,000,000-gal. centrifugal pumps at the Torresdale filter plant at Philadelphia, and I realize the difficulty not only of securing full contract efficiency when pumps are new, but also the difficulty of maintaining the same high efficiency after a period of use.

The cost analysis and financial balance upon which the type of pump is decided presupposes the maintenance of the assumed efficiencies throughout a long period. If this anticipation is not fulfilled it is easy to see that the conditions upon which we have predicated the type of pump have totally changed. As a case in point, the Buffalo water-works operates large electrically driven centrifugal pumps whose impellers have repeatedly shown remarkable deterioration. After a few months' service these pumps show a falling off of capacity and efficiency.

Mr. HENRY L. LYON, DEPUTY WATER COMMISSIONER, Buffalo, N. Y.: We have all sorts of trouble with the impellers, causing the efficiency to run down very materially. Upon taking the machine apart and looking at the impeller we found they were very badly corroded. We attributed it to the fact that at times we have some fine sand in the water, and the rapid revolutions caused the sand to have a sand-blast effect, wearing out the impeller blades to such an extent that the efficiency dropped from 68% down to 40%.

Safety in Railway Operation is being advanced by concerted effort toward that end, according to a statement in the presidential address of H. T. Bentley (Chicago & Northwestern Ry., Chicago, Ill.), before the recent convention of the American Railway Master Mechanics' Association. Mr. Bentley said in part:

About 18 months ago an organization was started on the Chicago & Northwestern, in a very humble way, for the purpose of trying to reduce the number of accidents that were occurring daily on our tracks, in the movement of trains and in our shops and roundhouses. The plan worked out so well under the forceful leadership of the general claim agent, and with the assistance of the members of the central safety committee and the local committees on the various divisions, and the results were so gratifying, that the scheme was quickly taken up by all of the large roads in the country. At one time it was thought that most accidents were inevitable, but when live safety committees got into action it is remarkable how quickly this idea changed, and a reduction in 16 months (the latest date for which figures are available) of 107 persons killed and 3996 persons injured on the Chicago & Northwestern, shows what can be done when men make up their minds that it is better to cause a delay than to cause an accident. The fact that it is possible to make such a remarkable showing has induced the railway commission of Indiana to ask all the roads in that state to go and do likewise. Before long the federal government will probably step in and call for some action that will help this good cause along; if it would only pass a trespass law and enforce it, a large number of the 5000 men, women and children who are being killed each year, because of the dangerous track-walking habit, would be saved.

A Very Large Reinforced-concrete boat has recently been built for the use of the Manchester Ship Canal Co. in England. This boat is described in the June 14, 1912, issue of London "Engineering." From that account we have made the following abstract:

The boat in question is known as a sludge pumping pontoon. It has been built for the purpose of enabling dredged material to be deposited on low-lying land anywhere along either bank of the ship canal. The pontoon will be towed by steam tugs to selected points and there moored. The hopper barges will then be towed from the dredges as they are filled and moored alongside the pontoon. The suction pipe of the pontoon will be lowered into the barge to be discharged and the delivery pipe will deliver material upon the area selected for its reception. The pontoon is equipped with its own boilers and engine for the pumping operation described. It is 100 ft. long by 28 ft. wide, and 8 ft. 6 in. deep from the keels to the main deck, drawing about 6 ft. 6 in. of water when fully loaded. Its entire construction, including four water-tight bulkheads and settings for the boilers and engine, is of reinforced concrete. The pontoon was built according to the Hennibique system by the English agents of that system, Messrs. L. G. Mouchel & Partners.

Steam for Propelling War Vessels was first used by the United States, according to a paper in the "Proceedings of the U. S. Naval Institute." The first steam vessel of the Navy was the "Fulton I," built at New York City in 1814. She had two separate hulls with a propelling paddle-wheel between them, the engines being in one hull and the boilers in the other. This vessel remained in the New York Navy Yard practically her whole life, being used as a receiving ship much of the time, and was finally destroyed there by an accidental explosion on June 4, 1829. The next steamer built was the "Fulton II," a small paddle-wheel vessel used by the navy for many years and finally wrecked near Pensacola in 1859. A small tug called "The Engineer" was purchased in Baltimore for the navy in 1836.

Apart from these isolated experiments in the use of steam in the navy, the first U. S. war vessels propelled by steam were the "Mississippi" and the "Missouri," built under the personal supervision of Commodore N. C. Perry and completed in 1841. These two sister vessels had each a displacement of 1692 tons. They were propelled by paddle-wheels 28 ft. in diameter and 11 ft. width, driven by two side-lever engines which were furnished with steam from four copper boilers carrying a pressure of 12 lb. The average speed was 11 r.p.m. Nearly 800 lb. of coal per hr. were consumed and the nominal horsepower of the vessels was 458, the actual 650. Besides their steam power the vessels were rigged as frigates and carried 19,000 sq.ft. of canvas. The "Mississippi" sailed twice around the world and was finally burned to prevent capture during the Civil War on Mar. 14, 1863.

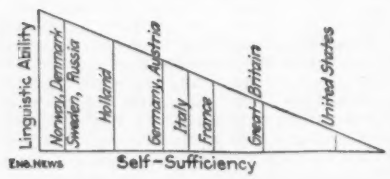
Letters to the Editor

A Diagram of National Linguistic Acquirement

Sir—Our suburb was recently honored by being made the meeting place of the Twelfth International Congress of Navigation. The occasion brought to us delegates speaking many tongues, and reminded me of a long-held view as to matters international and linguistic. This view is very crudely indicated in the accompanying diagram (which is necessarily drawn without a scale). Very likely the line should be concave (upward or downward) rather than straight.

The Scandinavian who would obtain an audience for his sayings or writings, must use some other than his native tongue, which is used only in his own little corner of the world. Hence the Scandinavians are excellent linguists.

On the other hand, the American writes and speaks a nearly universal language, and those who come here must speak English or remain silent. Hence



the American who knows anything of foreign languages is a rarity.

In the diagram I have sought to indicate the reciprocal self-sufficiency and linguistic ability of some of the nations best illustrating this view. Thus Russia is classed with the linguistic nations, notwithstanding her great size and population, because she is relatively isolated by her geographical position, by racial differences, and by the apparent unlearnability of her language by Western nations.

Until a few generations ago, France was the leading nation of Europe. Her language is still (I believe) the language of diplomacy; and the influence of heredity places her lower, linguistically, than Germany, which, until lately, was a second-rate power, and whose people, therefore, are better linguists than are the French.

Other things being equal, the prodigious self-sufficiency of our English brethren should place them at the extreme right of the diagram; but other things are not equal. Their proximity to, and their relatively intimate business and political relations with, continental Europe, render them much better linguists than ourselves.

JOHN C. TRAUTWINE, JR.
257 S. 4th St., Philadelphia, Penn.
June 29, 1912.

Concrete Column Economics

Sir—The article in your issue of June 6, 1912, p. 1070, entitled "Concrete Column Economics," by J. Norman Jensen, is an extremely interesting one. It is, however, to be regretted that the conclusions which Mr. Jensen arrived at are not more in keeping with the tables which he presented.

Mr. Jensen states that "for the same load, the same mix, the same percentage of vertical steel, but different percentages of spiral steel, the column with the *lowest* percentage of spiral steel is the cheapest." In Table IV of the article referred to it will readily be seen that the columns in which 1½% of spiral is used are cheaper than those having 1% or ½% of spiral. His tables show very clearly that the cheapest reinforcement is spiral hoops, and that for the same load, the same mix, the same percentage of vertical steel, but different percentages of spiral steel, the column with the *highest* percentage of spiral steel is the cheapest.

On an uptodate building ordinance, such as that of the city of Chicago, the principles of economical column design should be:

1. Never use tied reinforced-concrete columns, except for loads where the minimum side of the column allowable requires not more than 1% of vertical steel.
2. Use spirally hooped reinforced-concrete columns, wherever the percentage of vertical steel for the "tied" column would exceed 1% and use as much spiral steel as possible and as little vertical steel.
3. The richer the mix, the cheaper the column.

My conclusion therefore is that the cheapest column under a given load, when the size of the column is not governed by the minimum size allowable, is the column of 1:2:3 concrete, in which the vertical and spiral steel amount to about 3%, 1½% of which is spiral.

W. STUART TAIT.
Chicago, Ill., June 11, 1912.

[Mr. Jensen submitted a great number of tables giving the variation in cost of columns with a change in every variable noted in his article. Restrictions in space forbade the publication of all of these tables and the ones printed were selected with a view toward explaining Mr. Jensen's method rather than as a complete exposition of his work. This clears up Mr. Jensen's statement as given below. —ED.]

Sir—In reply to Mr. Tait's letter I beg to advise that Table IV of my article does justify him in his criticism. It will be noticed that even in this table the cost of a 1:1½:3 mix with 2% vertical steel and ½% and 1½% spiral steel is identically the same, and for the most economical columns the difference in cost is not very much. It is unfortunate that the complete tables as submitted to the editors were not all printed, as the statement that the writer has made is correct for the total loads of 442,000 and 595,000 lb., although it is apparently wrong in the lighter load of 285,000 lb.

The writer does not agree with Mr. Tait's conclusions, especially the second statement.

J. NORMAN JENSEN,
Architectural Engineer,
Dept. of Bldgs.
Chicago, Ill., June 24, 1912.

Concerning Special Technical Training

Sir—The address to the students of the Rose Polytechnic Institute printed in your issue of June 20, is the best exposition I have seen of the relation the technical graduate bears to society in its different aspects. May I be permitted to add a few words suggested by the following paragraph therein?

> I have to tell you, then, that so far as the engineering science you have learned in college is concerned, the supply of such learning is far in excess of the demand, and this excess of supply over demand is reflected necessarily in very low rates of pay for engineers.

The economic problem which faces every young man about to enter a profession, is how to place himself where there is a great demand for his services as compared with the supply of such services. It is probably safe to say that not one in a hundred ever gives a thought to this fundamental proposition. The ordinary procedure, which we witness every year, of a large body of youths taking a course in some subject which appeals to their whims or fancies, and then appearing simultaneously before the industrial world with similar training necessarily results in a great supply of men for whom there is no corresponding demand.

At the present time, the college curriculum is regarded by the average student

as the entire field to be covered by the aspirant for technical knowledge. Is this not a mistake? I believe that every youth should enter upon his technical education with a definite plan of action whose object is to prepare him for some special place in the industrial world where there is a demand for men of his special training. This, as a rule, requires the experience and knowledge of a parent or guardian, owing to the inexperience of the young man himself. The college should then be regarded as an instrument to execute certain parts of this plan.

For example, instead of giving a youth a training uniform with that of several hundred competitors who are to appear before the industrial world as aspirants for positions, he may be given a training designed to fit him for the mechanical engineering work of a silk mill. There is no course for silk experts at the colleges, so an educational plan of campaign like the following might be prepared:

1. History of silk.
2. Cultivation of the mulberry, etc.
3. Growing silk worms.
4. Preparation of cocoons.
5. Grades of raw silk.
6. Importation of silk.
7. Textile machines, design and operation.
8. The uses of silk.
9. Exportation of silk.

Etc.

The course must necessarily include as much mathematics as are likely to be found useful in the engineering side of the silk industry, and a thorough grounding in the principles of mechanics and electricity, but should not include railroading, surveying, structural-steel design, dynamo design and the other favorite college topics. Some parts of the curriculum can best be pursued at college; some elsewhere. In order to follow out such a plan, the student will have to spend some time at college, some under special tutors, some in the field, some in offices, and some in the mills. He may even earn a little money during the practical part of his course, so that such an education would probably cost less than a straight college course. When he has reached the end of his schedule he will find himself equipped with knowledge different from that of others and if he has chosen his field wisely, there will be a demand for his services. Furthermore, the precise methods of reasoning and general training learned at college will put him at an advantage over others in the industry who have not received an equal training.

I have known of several successful applications of this method; one a course in cotton culture, which necessitated the inauguration of a special department in one of our Southern colleges; another a course in machine-shop management (before that became a regular profession), and yet another, a course in refrigeration applied to food preservation and transportation. In two of these cases, the schedule of education was prepared by the parents, in one by the student himself. The men educated in this way acquired *wisdom* as well as *knowledge* and made more widespread and useful social connections than the average student of a technical college.

I do not want to give the impression that I favor the extension of practical training at the expense of theory. On the contrary I am in favor of having the student devote more time to the acquisition of fundamental notions than is now done. My stand with regard to practical training is that it should be largely *eliminated* from the college course, because it has been standardized, and the colleges are turning out too similarly trained men. What practical training is to be given by the colleges should be along more diverse lines and should be chosen by the student in accordance with a well thought out plan.

Let me recapitulate by saying that technical education should be carried out according to an intelligent plan of campaign directed toward placing the student where the demand for his services will be great compared to the supply of such services.

WM. A. DEL MAR.

Room 4149, 70 East 45th St., N. Y.,
June 25, 1912.

Stresses Due to Peripheral Eccentricities of Circular Tanks

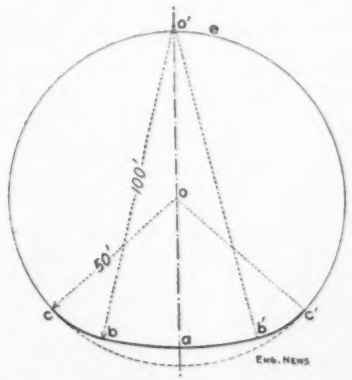
Sir—There appeared in ENGINEERING NEWS, Apr. 25, 1912, p. 770, an abstract of a paper read by Alexander Potter before the New England Water Works Association, in which the author maintains that slight irregularities in circular reinforced-concrete tanks induce secondary ring stresses which are relatively more severe in large tanks than in small ones; thus limiting the safe diameter to less than 200 ft.

Analysis shows that this is incorrect. The error seems to lie in the assumption that the tensile ring stress at any point in the wall of a tank filled with water is proportional to the radius of curvature of the wall at that point.

Assume the tank *cec'*, in the accompanying figure, in which the arc *cec'* has a radius of 50 ft., while *bab'* has a radius of 100 ft.; the arcs *bc* and *b'c'* have some intermediate, and not necessarily uniform, curvature. If the ring is taken at a depth where the intensity of water pressure is 300 lb. per sq.ft., the arc *bc* will tend to be pulled toward *e* by the ring tension 50 × 300 lb., and toward *a* by the ring tension 100 × 300 lb. The difference (100 − 50) × 300 lb. will tend to move *bc* toward *a*.

Now, the water pressure against *bc*, being all normal, cannot offer any resistance to this motion. Some outside force, coming either from the stiffness of the wall *ce* itself, or from its connection with the bottom of the tank or other immovable parts of the tank, must come into play. If the wall is perfectly flexible *bc* will at once move the very small distance, a small fraction of an inch, necessary to allow *ab* to assume the same curvature as the rest of the tank. This is merely saying, in other words, that for normal fluid pressure of uniform intensity, a circle is the only flexible equilibrium curve. Any other curve will deform into a circle under those pressures, and the large secondary ring stresses cannot be developed.

But the wall of the tank has stiffness. Computation shows, however, that with the thickness of wall, and the amount of reinforcement required to take the ring stress, a small fraction of one pound, applied at *b*, will make the wall *ce* deflect so as to allow *ab* either to assume the sharper curvature of the rest of the tank, which it cannot do, or to act as a beam in bending, which it really does. In other words, the ring stress cannot appreciably exceed 50 × 300 lb.



It can be shown that the bending moment in *bab'* is very nearly equal to 50 × 300 × *E*, where *E* is the constant irregularity, ½ in. in 10 ft., mentioned in the article under discussion. If *E* is constant for all sizes of tanks, then the bending moment increases directly with the radius for which the tank is designed. But both the amount of reinforcement, and, to a certain extent, the thickness of the wall, also increase with the radius. The section modulus of the wall, upon which the fiber stress in the steel depends, increases faster than the radius. Hence the fiber stress decreases as the tank increases in size. Actual computation shows that this fiber stress is of really secondary importance.

There is a precise method of analyzing the stresses in the walls of irregular tanks; but on account of its complexity it cannot be given here. It shows, how-

ever, that there cannot exist such variations in the ring stress as tabulated in the article; and that the irregularities in the steel stress, which come from the local bending moments caused by the same irregularities, decrease as the size of the tank increases.

JACOB FRIEDLAND.
664 E. 170th St., New York City.
May 26, 1912.

Grass Soil Binders for Protecting Embankments from Erosion

Sir—I recall an article in ENGINEERING NEWS several years ago referring to a practical way to get the slopes of large embankments covered with vegetation. If you can locate this article, will you kindly reprint the same, not alone for my exclusive benefit, but as a matter of general information?

AN OLD SUBSCRIBER.
Perry, Iowa, June 19, 1912.

[The article to which our correspondent refers was published in our issue of Apr. 24, 1902, p. 341. It was an abstract of a paper published in 1895 by Prof. F. Lamson-Scribner, then Agrostologist to the U. S. Department of Agriculture. This article deals with a variety of grasses which have been used in many localities for binding sand and soil, principally for the protection of sandy coasts from the destructive agencies of waves and winds.

For holding embankments, where a firm turf is required, Couch or Witch grass does excellently in the Northern and Middle States. It presents a number of forms, and all are good hay grasses; but they are objectionable in fallow lands owing to the widely spreading and very persistent jointed rootstocks. Couch grass makes a very tough sod, and is particularly valuable in binding railway embankments, banks of canals, ditches, etc.

Hungarian Brome grass is a good turf former and may be used in much the same way as Couch grass, though the creeping rhizomes are not so strong as the latter. In the Southern States, where Couch grass does not succeed so well, Johnson or finer Bermuda grasses may be substituted. The Johnson grass produces a great mass of widely creeping strong rhizomes, and when it once fills the ground it is almost impossible to eradicate it. Bermuda grass grows more upon the surface; upon a light sandy soil it succeeds better than Johnson grass. Bermuda grass is of great value in holding levees of sand, or loose soil; and it is at the same time one of the best pasture grasses of the South. If the land is moist and the soil somewhat clayey, Knot grass may be substituted for the Bermuda; and this Knot grass is especially well adapted to cover silt or bare slopes on the banks of ponds or rivers. Moderate submersion does not injure it.

The best methods of propagating sand-binding grasses have never been very closely studied, so far as we are able to determine. Their propagation may be effected by seed, where the seed can be procured, but the better way in most cases is to collect and transplant cuttings of the creeping rhizomes. A comparatively small amount will serve to cover a considerable area. The rhizomes may be cut into single joints, and every joint will serve as a new plant.

Specification clauses for protecting embankment slopes were given in ENGINEERING NEWS of Sept. 29, 1904, p. 288, and we reprint those relating to protection by grasses as follows:

> The contractor shall seed all surfaces of the embankments which have been finished with top soil and other surfaces as may be directed.
>
> The surfaces to be seeded shall be carefully prepared and raked over, and then seeded with grass seed, using at least 50 lb. per acre, and consisting of a mixture of 4 parts beech grass, 4 parts Hungarian Brome, 4 parts orchard grass and 1 part white clover, together with not less than 400 lb. of raw bone fertilizer per acre, and all well rolled. All seeded surfaces shall be carefully tended by the contractor. . . . .

Embankments may often be protected by sodding. It is not necessary always to cover the full area of a slope; yet how small a percentage of the full area may be sodded with satisfactory results is not often considered. The following clause from a levee specification throws light on this point:

> After the embankment is built to the proper height, and dimensions, it shall be smoothly dressed to proper slopes and the entire surface planted with living sods of Bermuda grass not less than 4 in. square, placed not more than 2 ft. apart. The sods shall be covered with 1 or 2 in. of earth as directed.—Ed.]

Regulations for Concrete Flat-Slab Floors Adopted by the Building Department of Portland, Ore.

Sir—The accompanying general regulations for the calculation of reinforced-concrete flat-slab construction are being sent by the Department of Buildings of Portland, Ore., to those doing business in this form of construction. This method of calculation has been followed in the department for about two years, but has never before been put down in the form of general regulations.

As the number of systems is increasing and the use of construction becoming more general, it has been thought desirable to make generally known the basis of calculations used in the department. It is hoped that this may do some small part toward the standardizing of the various methods now used in the calculation for this form of construction.

H. E. PLUMMER,
Inspector of Buildings.
Portland, Ore., June 21, 1912.

GENERAL BASIS OF CALCULATION OF REINFORCED FLAT-SLAB CONSTRUCTION

[Regulations Adopted by Building Dept., Portland Ore.]

It has been necessary for the Department of Buildings to use a general method of calculation for the purpose of checking any system of reinforced-concrete flat-slab construction, because there is a large and increasing number of systems and the advocates of each make special claims for their own system and have individual methods of calculation, many of which are not susceptible to a rational analysis to determine if the stresses allowed in the building code were adhered to in the design.

As the general procedure and methods used in checking by the Building Department may be of interest, they are herein stated with the hope that designers may be relieved from the annoyance of changing the plans of such systems after they have been submitted to the Building Department.

Any reinforced-concrete flat-slab construction can be separated into two main parts; first, the cantilever portion (extending out from the column), and second, the suspended portion. The first step in the analysis is to determine the extent of each. The Building Department leaves the designers free to assume the size and shape of the cantilever portion with the limitation that the diameter of such portion should not exceed one-half the distance center to center of columns plus one-half of the diameter of the column cap. The flare of column cap should not be less than 60° from the horizontal. The designer is also free to assume the proportion of the load carried by any reinforcing band, where two or more bands are under such load. The suspended slab is figured as freely supported.

The suspended load is considered to be uniformly distributed along the edge of the cantilever portion and the bending moment of the cantilever is figured in the usual way. The maximum bending moment of the cantilever is considered to be resisted by a width of slab greater than the width of the support, according to the conclusions of Prof. A. N. Talbot, after a series of experiments, and his recommendations are followed, which are as follows: The effective width of cantilever shall be taken as the width of the support plus twice the depth from compression face of slab to center of tension steel, plus half the remaining distance to the point of inflection or the edge of the cantilever. The resistance of this effective width is figured in the usual way.

Steel should be placed in accordance with assumptions made by designer so that all stresses are adequately resisted.

In all cases the stresses allowed in the ordinance are adhered to.

Punching shear is figured around the perimeter of the column cap, but in figuring diagonal tension, the resistance to maximum load is figured around a perimeter one-half the effective depth of slab out from the edge of the column cap.

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Engineering News

The investigation of rail wear in the Simplon and other Alpine tunnels summarized on another page does not mean that the rail corrosion and abrasion observed in these tunnels is greatly in excess of or different from that found in American railway tunnels. The novelty of the case lies in the fact that electric traction has been used in the Simplon since its opening, and the usual smoky atmosphere could, therefore, not be held responsible for exceptionally high corrosion. That moist tunnel air is hard on rail metal has been recognized ever since railway tunnels were first operated, but the part played by the smoke and its contained corrosive gases has been generally over-estimated. We may judge from the results in the Simplon and their comparison with results in other Alpine tunnels where steam operation prevails that the corrosion due to smoke gases plays an insignificant part in the phenomenon of rail wear in tunnels.

The essential important fact proved by the investigation reported is that the rate of corrosion or wear varies directly with the absolute moisture content of the tunnel air. With large inflows of water, it is impossible in the longer tunnels in the Alps to keep the air much below saturation throughout the greater part of the length of the tunnel, in spite of artificial ventilation. The heat of the tunnel has importance in direct ratio to the larger amount of moisture which the air can carry at the higher temperature, as the curves which we reproduce make evident.

The cure for rapid corrosion then is to make the tunnel as dry as possible, a very simple and obvious conclusion, and we may then feel certain that other factors, in particular the alternating-current rail return, have but little influence. We may also have the comforting assurance that smoke corrosion is unimportant at the floor level, whatever its effect may be upon metal at higher elevation within the tunnel.

A Fine Record for Safe Railway Operation

We have often pointed out in these columns that the accident record of American railways, takes as a whole, is little short of a national disgrace. A study of statistics, however, shows that the reason for this bad accident record is that certain railway companies are negligent with respect to safe appliances, safe methods of operation and organization and discipline of employees. There are other well managed railways which maintain a high record of excellence in the safe conduct of passenger traffic.

The Pennsylvania R.R. has just made public the statement that in 1911, on all the lines of the system west of Pittsburgh and Erie, which carried over 32,500,000 passengers, not one was killed as the result of a train wreck. The record of safe operation on these lines, however, goes back much farther than this; for it is stated that during the past five years, with the exception of the year 1910, when three passengers were killed in an accident, these Western lines of the Pennsylvania system have a clean record for passenger casualties resulting in death during that time. In figures, the statement is that of the 151,800,000 passengers carried on all lines of the Pennsylvania system west of Pittsburgh during the five years from 1906 to 1911, inclusive, the three passengers mentioned were the only ones killed as the result of a train wreck.

The Relation between Wind Velocities and Pressures

Notwithstanding the multitude of experiments on wind pressures which have been carried on since the days of Smeaton, there is still more or less uncertainty as to the actual pressures produced upon structures by high wind velocities. A discussion in these columns a few months ago relative to wind velocities and pressures recorded in a heavy storm in New York City well illustrates the confusion which exists even in circles where scientific accuracy is supposed to obtain.

In the present issue we give space to a paper describing recent experiments on wind pressures at the University of Nevada. Instead of making experiments upon a small model, where there is always room for large error as to the relation between pressure on the surface itself and the pressure due to the frictional resistance against the periphery, Prof. Boardman, of the University of Nevada, exposed to the wind a surface of large size, forming part of an actual building, and measured the pressure against it. The results of Prof. Boardman's tests indicate that the present methods of computing wind pressures from velocities err very largely on the side of safety. Wind pressures are generally assumed to vary approximately as the square of the wind velocity; but these tests raise a doubt whether the pressures may not vary as a somewhat lower power of the velocity. These tests confirm the impression which engineers have generally entertained that wind pressures against large areas are

very much lower per square foot of surface exposed than would be the case if these areas were cut up into smaller surfaces. Thus, for example, the pressure per square foot against the exposed surface of a bridge truss is doubtless very much greater than would be exerted against a surface of square form having an area equal to the total surface exposed by the bridge members and placed against the side of the truss.

It is probable also that inertia plays a large part in determining the final wind pressure against a structure. In the heavy wind storms which alone test the resistance of a structure to wind pressure, the heaviest wind comes in sudden gusts. The pressure set up by such a gust has to overcome the inertia of the mass against which it acts before it can produce serious stress.

It is perhaps worth consideration whether valuable data might not be gained on the actual wind pressure on structures by applying an extensometer to the wind bracing of a structure during heavy wind storms. The accuracy of such instruments is now such that in this way we ought to be able to gain a very fair idea of what stresses are actually being induced in structures by heavy storms.

The End of the Dirigible Balloon

The tragic death of the Vaniman brothers and their assistants by the destruction of their dirigible balloon at Atlantic City last week, coming only four days after the wreck of the Zeppelin dirigible balloon "Schweben" at Düsseldorf, Germany, ought to be sufficient to put an end to further waste of money and of human lives upon this mistaken plan of aërial navigation. There has been abundant experience now in Germany, in England, in France and in the United States to prove that the huge dirigible balloon is inherently a most dangerous craft. It is indeed possible with modern materials and mechanical appliances to build such balloons of huge size and to navigate them *under favorable weather conditions*. But all such balloons are extremely costly to build, extremely fragile and extremely short-lived. It is, of course, not impossible that such a craft might be built in which a sufficiently venturesome party might make a trip across the Atlantic; but its successful accomplishment would prove nothing, as the inherent danger of huge aërial craft of this type would remain absolutely unchanged. As far as the use of aërial navigation in warfare is concerned (as to which we have hitherto pronounced ourselves most skeptical) the possibilities, so far as possibilities exist, are entirely on the side of the aëroplane as compared with the huge dirigible balloon. Like the spherical balloon, it offers a huge, inviting and most vulnerable mark to the riflemen of an enemy. It could not hope to approach near enough to an enemy's lines to obtain any valuable information without running imminent risk of capture or destruction. Added to this is the fact that the dirigible balloon can only be used under favorable weather conditions and is tied almost as closely to a short radius of action from its protecting house as is a trolley car to its power station. It may well be expected, therefore, that a few years hence the craze over the dirigible balloon during the first decade of the twentieth century will rank among the curiosities of mechanical engineering.

Meanwhile the inherent danger of aërial navigation with aëroplanes is also finding almost daily exemplification in the rapidly lengthening list of fatalities. The two English army officers who were killed on July 5 makes a total of 159 killed since aviation began. It is noteworthy that the accidents occur not alone to careless and inexpert amateurs but to the most experienced operators. Indeed, most of the men who won fame two or three years ago by their exploits with the aëroplane have now been removed by death.

It is customary to regard with horror the brutality of the ancient Romans, crowding to witness gladiatorial combats in the arena, and to wonder at the enjoyment the Spaniard takes at the bull fight with its accompaniment of blood and danger. But the crowd assembled at an American fair in 1912 to witness an exhibition of flying is watching performers who put their lives in greater jeopardy than the Spanish bull fighter and suffer very likely a greater percentage of fatalities than the Roman gladiators.

A Moving Platform for New York

At last, after years of backing and filling, definite steps have been started toward building a moving-platform rapid-transit line in New York City. The project has been brought up often enough in the past, but at no time was the outlook such as to justify one in predicting an early realization of the project. The present outlook, however, is in every respect favorable, and the existing situation in rapid-transit matters in New York City makes the moving platform a logical thing for relatively short transfer lines; at least a full-size try-out is not only justified but is urgently necessary to New York's future interests.

The route chosen is a short crosstown route, which upon completion of the new north-south subway lines (part of which is now under construction) will intersect five or six main-line rapid-transit routes and ten north-south street-car lines. Moreover, the route passes through the center of an amusement and retail shopping district of maximum activity, with strong prospects for still further increase. The congestion along parts of 34th St., the location of the proposed route, is even now such as to overtax the available facilities for communication. The terminus of the Hudson tunnel system and the new Pennsylvania R.R. Station have contributed in no inconsiderable degree toward bringing this congestion to a point where relief is imperative. The traffic needs are in every way such as call for a railway of maximum capacity within the available street clearance; therefore, the moving platform, which makes its chief appeal on the point of great passenger capacity, gives logical promise of meeting the requirements. It is not necessary to think of future extension of the line, in the case of the 34th St. crosstown route, as crosstown traffic is pretty definitely restricted within the limits of the proposed route, Second Ave. to Ninth Ave., a distance of approximately one mile. Extension beyond these limits is not likely to be necessary at any time in the future. Thus the one serious point in moving-platform construction and operation, namely the undesirability of operating great lengths of continuous line (or facing the probability that the future might call for extension to a considerable length), is in this instance not in question.

Since all the circumstances of the case are favorable to the possibilities and operating requirements of the moving platform, we feel justified in looking hopefully toward the realization of the project which the Public Service Commission is now putting forward, at the right psychological moment. It is important in the interest of rapid-transit development in other cities that the full possibilities of the moving-platform method be demonstrated by its actual operation under heavy-traffic conditions.

The Collision on the Lackawanna Railroad near Corning, N. Y.

The disastrous train wreck on the Lackawanna R.R., near Corning, N. Y., in the early morning of July 4, is the most serious collision which has occurred under the block system for a long time. The record of casualties is 39 killed and 60 seriously injured. Considering the fact that the heavy locomotive hauling the express train which struck the rear of the standing passenger train, telescoped two day coaches and went part way through a steel pullman car, it is fortunate that the casualties were not even greater, especially as the night before July 4 is always a time of exceptionally heavy passenger movement. All the testimony now available indicates

that the engine runner of the express train was at fault. He ran past the block signals which were set against him and also passed the rear flagman of the standing train who had gone back 2000 ft. with his flag and had, it is stated, lit a fusee which was burning brightly when the express train passed it. There was some fog at the time and it was on this account that the flagman lit the fusee.

This section of the Lackawanna is equipped with automatic block signals of the banjo type. These signals are perhaps not as easy to identify in a poor light as a semaphore signal, but they are extensively used on many roads with results on the whole satisfactory.

According to the official statement of the Lackawanna company, the engine runner of the express was a man 54 years old and had been on this particular run for 23 years. His past record was excellent and at the time of the collision he had been on duty only an hour. He passed, without slackening speed, the block signal 4750 ft. in the rear of the standing train which stood at "caution," the rear brakeman with his red flag and burning fusee, 2000 ft. back of the train and the home signal standing at "danger," 250 ft. from the rear of the train.

The accident is to be investigated by the New York Public Service Commission and the Interstate Commerce Commission, and it is to be hoped they may be able to elicit from the engine runner a frank statement as to the conditions which caused him to ignore all warnings and cause the worst wreck in the history of the Lackawanna R.R.

Doubtless this disastrous collision occurring under the block system revives interest in the use of automatic stops in connection with block signals. Possibly it may arouse the interest of some shrewd capitalist desiring to combine business with philanthropy to the extent of investing $100,000 or so in some one of the automatic stop systems which have been developed to the point where they promise mechanical success. If such a result should be obtained there would be good reason to hope that a successful automatic stop system may be made available to railways in the near future. As the United States Block Signal and Train Control Board has pointed out, if strong financial and business support were given to some of the best automatic stop systems which have been developed, the business might be placed on a sound, technical and commercial basis.

When one reviews the accident record of the Lackawanna, however, it is easy to see what a difficult problem, mechanical and commercial, the automatic stop system has to meet. The block-signal system works perfectly a hundred thousand or a million times. What is wanted is some supplementary device which will operate at the hundred thousandth or millionth time and prevent such disobedience to signals as caused the Lackawanna disaster. According to General Passenger Agent Cullen, of the Lackawanna, that road has carried 250,000,000 passengers in the twelve years preceding this accident with the loss of only two lives in a train wreck. Under these conditions, railway officers are properly cautious as to the installation of automatic stops. They are anxious enough to prevent disobedience to block signals, but they wish to be certain that the automatic stop itself will not introduce new dangers. Would the knowledge that an automatic device is going to stop the train back of the danger signal if he fails to do so, operate to make the engine runner in the cab less vigilant?

On the other hand, with the growing difficulty in securing first-class, reliable men for engine runners and with the pressure exerted by labor unions to interfere with the discipline of careless men, there are plenty of railway officers who would sleep more soundly if they knew there was some automatic sentinel which would make certain that when a signal orders an engine runner to stop his train, that stop would certainly be made, even though the engine runner were asleep at his post.

It is perhaps worth consideration whether the automatic stop system might not be made practicable as part of the flagging system. It is exceedingly difficult to maintain thorough, conscientious flagging under the block system, for the flagman knows that if the engine runner of an oncoming train can see his flag, he can also see the block signal displayed at danger. Under normal operating conditions, therefore, employees too often feel that back flagging under the block system is a useless formality. But if it were possible to provide the rear flagman with a portable automatic stop which he could set beside the rail and which would apply the brakes to the oncoming train even though the man at the throttle were paralyzed or a maniac or stricken dead with heart disease—under such conditions the rear flagman would feel that his work was something more than a superfluity. That there would be practical difficulties in working out such an idea may be admitted, but it is not clear that they would be any greater than have been met and solved in connection with many another problem of the railway service.

A Wreck Due to Bad Railroading

Close on the heels of the Lackawanna wreck came the news of another shocking collision, occurring on July 5, on the Ligonier Valley R.R., a local line in a coal-mining district of western Pennsylvania. A passenger train was being pushed by a locomotive on a short branch when it met a double-header coal train coming at high speed around a curve. Of course, the passenger car, having to stand the impact of the locomotives, was wholly demolished and nearly every passenger in it was killed outright or seriously injured.

It is an axiom of safe railroading practice that passenger cars when occupied should never be pushed by a locomotive. Only under emergency conditions, as in the backing up of a train in case of blockade, should such movements be permitted. On the Ligonier Valley R.R., however, it seems to have been the regular practice to run this particular train in this manner. The locomotive hauled the passenger train from Latrobe to Ligonier over the main line, and at the latter station detached the combination baggage and smoking car and backed the passenger car up to Wilpin, the end of the run. Doubtless some special layout of tracks and switches made this method of operation convenient; but the convenience was purchased at the price of safety, and the penalty has now been paid. Had the locomotive been running ahead, it would have borne the brunt of the collision and the casualties among the passengers would probably have been small.

It may be pointed out, too, that when a passenger car is being pushed by a locomotive, the chances of a bad wreck in case of derailment are much greater than if it is hauled in the usual manner.

It is, of course, true that operating systems should be such as to prevent such collisions as this. If it is too much to expect that branch roads of light traffic like this should adopt the block system, they might at least use the train staff or train-tablet system, which is in common use in Europe and is in fact compulsory in Great Britain on light railways not using block signals.

A Review of Locomotive Practice of Today

The special features represented in locomotive construction during a period of a year or two afford an indication of the tendencies in locomotive design, and a consideration of these features may point to some possible or probable lines of future development. Elsewhere in this issue we present information respecting features of locomotive design on certain railways during the year 1911, and this (supplemented by other information) affords a basis for a general review of the situation.

The most conspicuous feature, and one of the most important features of modern development is the increase in size and weight which has been necessitated by the constant demand for increased power. In fact this demand has resulted not only in very heavy engines and heavy axle loads, but these weights are approaching the limits of economical endurance (if not the limits of safety) of ordinary track

construction. This is especially the case when it is realized that these extremely heavy engines are by no means confined to roads or divisions having the heaviest type of track. Loads of 50,000 to 60,000 lb. per driving axle are very general, and a load of 68,800 lb. is reached on recent 4:4:2 passenger engines of the Pennsylvania R.R. It does not appear that these heavy loads are the direct cause of rail fractures to any extent, their effect being mainly to increase the wear and tear on the rails and track in general. On the other hand, however, there can be little doubt that they will tend very seriously to develop the failure of rails which are of inferior quality and weakened by internal flaws and defects.

Recent investigations indicate that such rails are undesirably numerous and widely distributed; therefore it is very evident that special care should be taken to examine and strengthen track which is to carry these very high concentrated and distributed loads. It is unfortunate, as has been pointed out at various times, that there is too often a lack of coöperation between the different departments of the service. If the operating department demands more powerful engines, the motive-power department will furnish them, and there may be little or no consultation with the engineering or maintenance-of-way department as to economic relations between engine loads and track structure. It seems to be one of the possible advantages of the Hines system of organization (which seems likely to be extended materially) that it will automatically promote such coöperation, since it provides for close inter-relations of the several departments, as was described in ENGINEERING NEWS of Mar. 3 and 10, 1910. But this is rather beyond the purpose of the present discussion.

The problem of weight is particularly difficult in regard to passenger locomotives, since high-speed service precludes the coupling together of more than three driving axles. Already we have axle loads of 60,000 to 68,000 lb., and the impact effect or hammer-blow of such loads at high speeds is very severe upon joints, frogs, low spots and the track in general. Balanced locomotives, designed to minimize these effects, are used only to a very limited extent. If further material increase in power and capacity are required for fast passenger engines, the problem becomes serious. It may be attacked in two different ways. In the first place, the attempt may be made to reduce the relation of weight to power, so that greater power may be developed on a given weight. This is possible by so designing the engine and its individual parts as to eliminate all excess or unnecessary weight. But this must not be carried to an extreme, or the wear and breakage of parts may become excessive and so render the engine uneconomical and unreliable. By the use of special metals (or alloy metals), however, it is possible to effect a material reduction in weight without any reduction of strength in certain parts whose weight otherwise would not permit of reduction. In the second place, a special design of locomotive may be introduced, having more than three driving axles, but with these axles arranged in independent groups.

Both of the above methods have been put into practice. As to the first, the American Locomotive Co. has built and put in trial service an engine of an ordinary type (4:6:2) which was designed throughout with a special view to combining a maximum of power with a minimum of weight and a reasonable allowance for strength and service. As to the second method, the Atchison, Topeka & Santa Fé Ry. has had in service for some time a passenger engine of the Mallet type having five driving axles arranged in two separate groups (ENGINEERING NEWS, Apr. 20, 1911). This latter engine, however, was designed for relatively fast work on very severe grades (1.75%), and its speed capacity probably is considerably lower than that of an engine of ordinary type. For slow speeds, of course, four coupled axles are practicable, and for regular speeds of 25 to 30 m.p.h. with heavy passenger trains on divisions having severe grades the Chesapeake & Ohio Ry. has introduced a special class of 4:8:2 passenger engines. One of these engines will pull trains which hitherto have required two 4:6:2 engines. The Southern Pacific Ry. also is using Mallet engines (of the 2:6:6:2 class) for passenger trains on a division having grades of 2.2%, but undoubtedly in such case the speeds are comparatively low and cannot be considered in relation to really high-speed service.

In England, locomotives with a single driving axle have been in common use for fast trains until within very recent years, and more than two coupled axles were considered quite impracticable for such trains. But the insistent demands for improved accommodation and the consequent marked increase in weight of passenger cars (and in weight per passenger) has driven most of the railways to introduce six-coupled engines for fast trains. The weight and axle loads, however, are much lower than in American practice; since the train loads are very much less. In this connection it is of interest to note that while compounding is regarded with very slight favor in England, many railways are using simple engines with three and four cylinders. One reason for this is that the interior limits of the frames and the exterior limits of the loading gage or clearance, prevent the use of cylinders of the very large diameter necessary to give the required power in a two-cylinder engine. With three and four cylinders the size and weight of individual parts is kept within moderate bounds, there is a better torque or turning moment on the axle, and probably there is a better equalization of the draft. Further, there is the balancing effect to be considered.

With freight engines there is greater possibility of increase in weight for locomotives of the ordinary type, since as many as five axles may be coupled. Such engines have been in use for some years, and have been introduced recently on a road under conditions which appear to indicate that they are considered more satisfactory than engines of the Mallet type. But when more than four driving axles are required it is a question whether an ordinary engine with five coupled axles or an articulated engine with two groups of three axles each will be the most satisfactory, the latter presenting advantages where curves are numerous and sharp. With the articulated or duplex type of engine the use of ten driving axles is practicable, and such engines have been put into actual service (ENGINEERING NEWS, May 4, 1911). An extension of the articulated system to comprise three groups of driving wheels (such as an engine of the 0:10:10:10:0 or 0:8:8:8:0 class) has been designed and covered by patents. But it seems highly improbable that such an engine will be built or would prove economical in service. However, a marked feature of locomotive development in this country, is the very extensive use of the Mallet type of articulated locomotive, since its first introduction about eight years ago. At first employed mainly in pusher service it has now become a standard type of road engine; in many cases it has been of great advantage in eliminating double-header service, hauling heavier trains with greater economy than the two engines formerly required. Recently, it has been introduced also for service in hump yards, pushing long trains up the grade to the summit, beyond which the cars run by gravity to the classification tracks.

An interesting feature in freight locomotive design is the development of the very common 2:8:0 (consolidation) type into the 2:8:2 (mikado) type. The 4:8:0 type is but little used, since with the large fireboxes of modern engines an extra trailing support at the rear end is of more importance than distributing the truck load at the front. However, it is of interest to note that a 4:8:2 (mountain) type has been developed, as noted above, although this is for heavy passenger service.

The boiler is the real foundation of the locomotive as a power plant, and its size already approaches the practicable limits. Indeed, so far as firing by hand is concerned, the capacity has been pretty well reached, for with 70 to 100 sq.ft. of grate surface it is difficult to maintain a good fire and economical use of fuel with an engine in regular road service. In fact, a grate having 100 sq.ft. is probably be-

yond the economical limit in this class of service. The new 2:10:2 engines of the C., B. & Q. R.R. have grates 8 ft. wide (88 sq.ft.), and Mallet engines of the B. & O. R.R. have grates 9½ ft. wide (100 sq.ft.). A further increase in grate area has been suggested by Prof. Goss as a means of increasing the power capacity of locomotives using poor grades of fuel; such an increase should result in a lower rate of combustion (per sq.ft. of grate per hour), and enable engines to make longer runs without cleaning the fire.* But with, say, 150 sq.ft. of grate, hand firing would be out of the question, and he proposes therefore to limit the width to 7 ft. (with a length of 20 to 25 ft.) and to use automatic stokers on either side. As a feature of this design, he proposes to carry the fuel in hoppers directly over the stoker magazines and extending above the boiler, so that the use of the tender as a coal carrier might be dispensed with. This would necessitate putting the cab forward of the firebox. Whether the advantages or economies would be commensurate with the disadvantages and difficulties due to such a special design is open to question, but the suggestion is interesting in itself and as indicating the limits which locomotive design has reached. It does not call for critical study at this time, however, as it is admittedly only a suggestion for possible lines of development. But at any rate the mechanical stoker appears to have passed the experimental stage, and it is being introduced for regular service on its merits as an efficient device.

Among the many features of firebox design intended to improve combustion or reduce repairs (or both) may be noted: 1, the Jacobs-Shupert firebox, which is built up of pressed-steel channels and dispenses with stay-bolts; and 2, the Gaines firebox with a vertical bridge-wall across the front end to form a combustion chamber in front of the tube plate. The use of the firebrick arch is increasing steadily, but still is not so general as in Europe. Another feature, which is by no means new and which seems to be employed less than formerly, is a combustion chamber forming an extension of the firebox into the barrel. As to the actual value of this construction there seems to be very little definite information. For large fireboxes of the stay-bolt type flexible stay-bolts are essential, and of common use, but devices introduced to make the sides flexible and so relieve the stay-bolts of any but direct stresses have been applied only to a limited and experimental extent.

As to the boiler barrel or steam generator, the increase in diameter is limited only by the clearance lines, and the maximum is probably about 8½ ft. But in length there is a limitation due to the low heating efficiency of the far end of very long tubes. At one time 20 ft. was considered the limit, but 25-ft. tubes are now used frequently, and apparently with satisfactory results. The effective length might be increased somewhat, perhaps, by the use of tubes of larger diameter, thus reducing the choking effect of the long small tube. But this would involve a reduction in number of tubes and in tube surface, and as (in any case) the first part of the tube is the most efficient, the greatest possible number of tubes is desirable. A diameter of 2¼ in. appears to be generally regarded as the maximum desirable. For a great length of boiler barrel it remains to be determined whether the greater efficiency is given by tubes of the entire length or by shorter tubes and a combustion chamber extending from the firebox into the barrel, as mentioned above.

However, the length of barrel may be considered as limited to 20 or 25 ft. Since the articulated locomotive admits of an even greater length of boiler, it has become usual to utilize the excess length for the location of feed-water heaters (and even superheaters) in order to increase the efficiency of the boiler plant. In other types of engines feed-water heaters are rarely used, and superheaters must be adapted to the tubes or the smokebox space. It may be noted also that in tests of Mallet engines of the same class with and without the feed-water heater, on the Norfolk & Western Ry., there appeared to be very little ultimate economy due to the heater.

One feature of locomotive design which is still far from satisfactory and which is still based largely on methods of rule-of-thumb and trial-and-error, is the draft or front-end equipment. It is designed and adjusted usually to insure good steaming capacity for the boiler, rather than with regard to fuel consumption and economy, and this use of the exhaust to create the draft involves a high back pressure which serves to reduce the power capacity of the machine. This matter was discussed editorially in our issue of June 12. At the present time, however, no other system of creating the draft is in use, although some experiments are being made in this direction.

The superheating of steam is becoming very general, and the results are admitted almost universally to be satisfactory and economical. There are certain difficulties in regard to lubrication and packing, and the wear of surfaces exposed to the action of superheated steam (as noted in our issue of May 2), but all of these have been disposed of satisfactorily in most cases. It is of particular interest to note that superheaters are being applied to switching engines, not so much to secure direct economy in fuel as to effect improvement in other ways. One special advantage is in reducing the cylinder condensation which is usually high on engines working intermittently. The consequent reduction in evaporation has an important effect (especially for engines working at city yards and terminals) in that less smoke is produced, since the engine can be fired more lightly. The ultimate result is an economy in fuel consumption in switching service as well as for engines in road service. In several cases the introduction of superheating is accomplished by a reduction in boiler pressure, even to as low as 175 lb. This is of advantage in the design, weight and repair of boilers. As a general thing, however, 200 lb. is an ordinary pressure, and is exceeded (to as high as 210 lb.) in many cases.

But while superheating is now in great favor, compounding has undoubtedly lost favor, and is now employed to a very slight extent except in Mallet engines. Indeed, even here it has been excluded in at least one instance, that of the experimental engine of the Pennsylvania R.R., which has four 27-in. high-pressure cylinders (ENGINEERING NEWS, Apr. 4, 1911). The reason assigned for this is that a compound engine of equivalent power would require low-pressure cylinders of such diameter as to exceed the clearance limits. On the other hand, it is to be noted that the B. & O. has found it practicable to operate Mallet compounds having low-pressure cylinders 1 in. diameter, while Mallet pusher engines on the Virginian Ry. have 44-in. low-pressure cylinders.

Ordinary engines with more than two cylinders are rare, and these consist mainly of four-cylinder balanced compounds. A three-cylinder simple engine, however, has been under trial on the Philadelphia & Reading R.R. for some time. In Europe, engines with three and four high-pressure cylinders are used somewhat extensively, as noted already.

Coming now to the question of steam distribution, the Walschaerts valve gear has already superseded the Stephenson gear which for so many years was employed exclusively in this country. It is claimed to give a quicker or smarter movement to the valve, which is specially advantageous in giving good admission and exhaust at high speeds. Some roads have increased its value for high-speed engines by adjusting the lead so as to give an advantage in forward motion at the expense of the backward motion. However, this gear is used extensively also on freight engines and even on switching engines. One of its great advantages is in being entirely outside of the wheels, and leaving the interior space free for ample bracing of the frames. When first introduced, it had an advantage also in reduced weight of moving parts as compared with the Stephenson gear, but this has been lost to a large extent by increasing the size and weight of parts to insure ample strength. When introduced in 1905, the saving in weight on some passenger engines of the L. S.

*Engineering News, June 20, 1912.

& M. S. Ry. was from 1200 to 1750 lb., while on freight engines it was 1283 lb. (2382 lb. as against 3665 lb.).

A form of gear which has been introduced within recent years and appears to be growing in favor is the Baker-Pilliod gear, which (like the Walschaerts) is entirely outside and takes its motion both from the crosshead and a return crank on the main crankpin. Among special valve gears used to a limited extent are the Allfree and the Young, both of which are used as auxiliary to the ordinary Stephenson gear and have special designs of valves with short steam passages. The distinctive feature of the Young gear is the use of two Corliss rocking valves on each cylinder, one for admission and the other for exhaust. This use of separate valves is more extensive in Europe. The Joy valve gear (which is another outside gear) is used by two or three English railways, but we are not aware that it has ever been applied to locomotives in this country.

Another matter relative to valve gears is the use of power reversing gear, the introduction of which has been very slow in this country. It is difficult to see why this should be the case, since it is much more efficient and more easily handled than the heavy lever and quadrant still used almost exclusively. With Stephenson gear on a heavy engine at high speed, it requires considerable strength and skill to shift the reverse lever, and the natural result is that the lever is not shifted as often as it might be to adapt the steam distribution to the operating conditions. With the power gear (of which the screw gear is the most common) the distribution can be adjusted very closely to meet the conditions and with little effort, while there is no possibility of the gear getting beyond control, as in the case of shifting a reverse lever. Power gear is used mainly on Mallet engines, but there are many good reasons why it should be applied to engines of the ordinary type. However, the hand operation of the reverse lever is said to be much easier for the Walschaerts and Baker-Pilliod gears than for the Stephenson gear.

With modern developments in yard and terminal design and operation the humble switching engine has assumed a new importance in regard to efficiency and economy of service, although the character of the work does not conduce to high economy of steam or fuel. Nevertheless, superheaters and special valve gears have been applied with success to these engines, as noted above. The most usual type of switching engine is the six-wheeled engine with all wheels coupled, although eight-coupled engines are used in a number of cases. The use of trucks on engines in ordinary yard shifting service is exceptional, but is a feature on the latest engines of this class for the Baltimore & Ohio R.R., the truck being introduced in order to reduce the destructive wear and tear upon the track. This road had a number of 2:8:0 freight engines put in switching service, and several of these had the truck removed, but these led to such complaint as to damage to the track that the trucks have been replaced. The opinion on this road is that the truck is desirable for all heavy switching engines. In six-wheel switching engines, the more usual practice has been to make the middle pair the main drivers, but this involves the use of a very short connecting rod. For this reason, the rear wheels are now in many cases made the main drivers, and this design on the Erie R.R. has influenced the use of the Baker-Pilliod valve gear (apart from its inherent advantages).

In matters concerning locomotive development as related to traffic and operating conditions, it is of interest to note that while grade reduction is a common method of improving the traffic capacity there is an alternative in the adoption of locomotives of greater power to operate heavier trains on the existing grades. The latter method has been found advisable on the St. L. & S. F. Ry., as noted elsewhere, but the relative economy of the two methods must be considered in each case, and in some cases both methods will be used. On lines of moderate grades and heavy traffic the use of more powerful engines is practically the only method of increasing the traffic capacity so far as train loads are concerned, but the capacity in number of trains may be increased by the construction of additional tracks, as noted in the case of the Erie R.R. Where conditions are such as to necessitate the use of double-header trains, material economy may be effected by the introduction of engines of greatly increased power, since the one large unit should be much more economical than two independent units.

In most cases of this kind the Mallet duplex engine shows its advantages, as noted for the Southern Pacific and other roads. On a single-track division of the New York Central R.R. the introduction of these engines increased the traffic capacity 40%, 26 Mallet engines handling 1400 cars per 24 hours as against 1000 cars by 60 ordinary 2:8:0 engines, besides eliminating the pusher service required with the latter. However, this development is not confined to the articulated engine, and the Chesapeake & Ohio Ry. has introduced a special 4:8:2 class of passenger engine which takes heavier trains than those formerly handled by two 4:6:2 engines. The C., B. & Q. R.R., also, after experience with Mallet engines, has introduced a 2:10:2 type similar to (but much heavier than) the engines in use for some years on the A., T. & S. F. Ry.

The foregoing review of the locomotive situation is intended to show the lines of recent development embodied in the locomotive of today; and also to show some of the conditions governing or influencing this development, both as to the present and the future. The increasing demand for efficiency in modern railway engineering and operation, the approach of the locomotive toward certain limits of development, and the general growth of traffic are conditions under which greater attention must be given (and is being given) to measures for increasing the capacity, the power and the economy of the locomotive in relation to its size, weight and methods of operation.

The Need of a More Severe Soundness Test for Cement

By Henry S. Spackman*

The purpose of this paper is to emphasize some points in the conclusion and summary, at the close of H. J. Force's interesting paper on "The Autoclave Boiling Test for Cement," published in Engineering News, June 13, 1912, p. 1111, and to impress upon engineers the necessity of guarding against the possible danger, through latent power of expansion, lying in the coarser particles of clinker generally found in cement, and the need of guarding against it by employing tests other than those prescribed by the present standard specifications.

We do not agree with the latter part of the statement, under the heading of "Fineness," p. 20 of the U. S. Government Specifications for Portland Cement (Circular 53 of the Bureau of Standards), reading: "Only the extremely fine powder of cement, called flour, possesses appreciable cementing qualities, and the coarser particles are practically inert." On the contrary, we believe that these coarser particles may, under certain conditions, prove dangerous, and this danger has been recognized for a number of years.

In a joint paper, "Hydraulic Properties of Reground Cement Mortars," by R. W. Lesley and the writer (read before the Annual Convention of the Association of American Portland Cement Manufacturers, at its meeting in December, 1907) it was shown, not only that but a comparatively small proportion of the cement took any part in the cementing action, and that the larger proportion, even of the cement passing the 200 mesh, was practically unacted upon by water, even after long periods of submergence; but, also, that between these relatively coarse particles and the exceedingly fine active

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particles there were other particles of intermediate size which, on exposure to moisture and heat, might react and cause expansion.

Commenting, in the *Cement Age* of August, 1908, upon the report, "Portland Cement Mortars and Their Constituent Materials" (issued by the U. S. Geological Survey), the writer stated:

> This drop in tensile strength of normal cement, as shown by the breaking of standard briquettes, is not due to disintegration of the cement, or any deterioration, but to internal strains, probably developed by the later hydration of some of the particles.

In a paper, "The Relation of the Lime Content of Cement to the Durability of Concrete" (read before the National Association of Cement Users, in December, 1910), the writer again called attention to this fact, stating:

> It is also known that portland-cement clinker will decrepitate with time when exposed to ordinary atmospheric influence. . . . . It is also known that only a portion of portland cement ever hydrates or takes part in the hardening. It is, therefore, not unreasonable to suppose that this unacted upon clinker in the cement will disintegrate with time. Whether the disintegration of briquettes stored in air, or loss in strength, is due, in part, to the decrepitation of the coarse particles of the cement, as above indicated, or not, is at present a matter of speculation; but it would seem—in view of the well known action of clinker—that it would be desirable to have as little inert material in the cement as possible.

At an even earlier date, Dr. E. W. Lazell stated in a paper, "Mechanical Defects in Sieves Used for Testing Cement" (read before the American Society for Testing Materials, in 1904):

> It is well established that very fine flour which passes the finest sieve is the part of the cement which gives to it its binding property. This flour, owing to its fine subdivision, is the part acted upon by water, while coarser particles are slowly, if ever, attacked.

The writer's experiments give him every reason to believe that only some 30% of the average commercial portland cement becomes hydrated in seven days under the most advantageous conditions; that about 5% hydrates between the 7- and 28-day periods; and that a similar amount hydrates between the 28-day and 6-month periods; making a total of about 40% of the cement that takes part in cementing action during the first six months or a year, and of the remainder a portion, at least, continues to slowly hydrate through long periods of years, causing swelling or expansion of the concrete.

We concur absolutely in Mr. Force's statement that: "We are quite safe in saying that the failure of cement to pass the high-pressure test, or a sample to fail in the ordinary boiling test, is not due to free lime." The writer has been convinced for years that the expansion and swelling of cement and consequent disintegration of concrete was not due, in the majority of cases, to improper chemical proportioning and burning of the cement, causing what is generally called free lime, but to the expansion due to the hydration, after first hardening of the more coarsely ground and consequently less active particles of cement. We believe Mr. Force would have been justified in eliminating the qualifying words we have italicized from the following statement: *"It appears very probable that* if cement which fails on the high-pressure test, but which has passed the ordinary boiling test, is placed in certain structures it must necessarily still contain a large number of granules, which did not at the time the concrete was placed become moistened, or which took no part in forming the true cement. If a cement of this kind is placed in a structure, *it appears entirely possible that* in a few years moisture will work its way into the structure, and these granules will in time become ruptured, and so start expansion and disintegration of the concrete."

Before stating in detail what we believe to be the action of these relatively coarse particles, it may be proper to point out that the portland cement produced in the United States during the last 10 or 15 years differs materially, both in chemical composition and method of manufacture, from portland cement produced prior to that date, and from a large proportion of the portland cement now being manufactured in Europe.

In the early days the chemical laws covering the proportioning of the raw materials were not fully understood. Experience showed that when too much lime was used the cement was unsound and went to pieces in the work. Therefore, the manufacturer aimed to keep as low a lime content as was consistent with the development of reasonable strength at short periods. The lime and clay substances were generally ground together as a slurry, which was run off into vats, allowed to dry, and subsequently made into briquettes under pressure in the same manner as clay bricks are molded today. These bricks, after further drying, were placed in an intermittent or fixed kiln and burned. During calcination their temperature was gradually raised to a point sufficient to cause chemical combination of the lime and clay. As the time of calcination extended over a considerable period, and the material was closely compacted and in intimate physical contact, there was ample opportunity for diffusion and combination to take place, without the necessity of carrying the temperature to as high a point as required in the rotary kiln, and the resulting clinker was softer, more porous and easier to grind.

At present portland cement in the United States is produced exclusively by the rotary process, the raw material being generally fed to the kiln in the form of a dry powder, which in passing through the kiln is subject to constant movement and agitation. As the material is only in the kiln from one to two hours, this implies the rapid heating to the very high temperature which is necessary to bring about rapid chemical action. The clinker is also very quickly cooled.

On attempting to burn in a rotary-kiln cement of the chemical composition of that formerly produced, two difficulties are encountered: The material fuses in the kiln, adhering to the linings, forming rings, etc., making operation difficult, if not impractical, and the resulting cement is too quick setting, even when sulphate of lime is added. To overcome these difficulties, the average lime content of the cement was raised.

The clinker produced by the rotary process is much harder to grind than by the old process, so that rotary-kiln cement of the same degree of fineness as measured on the 100- and 200-mesh sieve contained less flour. The clinker is also denser and more resistant to the action of water. Owing to its high lime content, however, the rotary-kiln cement gives greater strength at short periods, but this increase in strength is not maintained over long periods; instead of a constant increase in strength when tested under tension, there is generally a marked drop in strength after the 28-day or 3-month period.

We do not wish to be understood as stating that all concrete made from rotary-kiln portland cement will ultimately disintegrate. We know that some has, and believe that more will, unless greater care is used generally by the manufacturers. We do not think that fine grinding alone will be found sufficient to overcome the danger, as with our present mechanical devices it is impossible to reduce all the cement to such fineness that it will react with the water during the earlier period of hardening. We believe the cement manufacturer must consider the physical characteristics of his raw materials, the ratio to each other of their constituents, their preparation and burning, together with the aging of the clinker and the subsequent aging of the cement, if he would produce a cement that will invariably pass the autoclave test, proposed by Mr. Force.

The constitution of portland cement and the process of hardening are still open questions. Much work remains yet to be done before we can state definitely what does or does not take place, either in the formation of portland-cement clinker or in the subsequent hardening of the powdered cement on mixing with water; although recent work done by Day and Shepherd in the United States and investigators in Europe has thrown much light on these two questions. The theory, however, most accepted is that portland-cement clinker consists chiefly of a non-homogeneous mixture of silicates and aluminates of lime of varying degrees of basicity, together with some uncombined lime (CaO), and that upon grinding and subsequent mixture with water, the more finely divided particles or flour immediately react with the water and set,

forming hydro-silicates and aluminates of lime. Only about one-half of the lime enters into the formation of these aluminates and silicates, which are present both in the crystalline form and as gels. The balance of the lime crystallizes out in the form of calcium hydrate. It would, therefore, seem that the set cement consists of a mixture of hydro-silicates and aluminates of lime, hydrated lime set free in hardening, and finely divided—but relatively coarse—particles of clinker, which have been but superficially acted upon by the water, but which may hydrate in time.

It is to these coarse particles of clinker and also in some cases to the hydrated lime formed during hardening that we attribute the disintegration and loss of strength that sometimes takes place in concrete.

Fresh portland cement has a specific gravity of 3.15 to 3.20; hydrated cement has a specific gravity (including the hydrated and unhydrated particles) of about 2.5 (the reduction in specific gravity being due to the hydration of only from 30 to 40% of the cement); the specific gravity of hydrated lime is known to be about 2.08; but the specific gravity of the hydrous calcium silicates and aluminates, formed in the setting cement, has not—to our knowledge—been determined, but it is probably as low, if not lower. It will, therefore, be seen that the hydration of portland cement must be accompanied by increase in volume.

As has already been indicated, portland-cement clinker is normally in a state of tension, which causes it to decrepitate and break down into smaller particles, this action extending over a considerable period.

It is also known that concrete is not constant in volume, but, on the contrary, is in continual movement through the expansion and contraction caused by changes in temperature and variation in the amount of moisture present.

It would seem logical, therefore, to assume that the strains produced by the constant changing of form, together with the natural tendency of clinker to decrepitate, would result in breaking down these particles of unacted upon clinker, exposing new surfaces to the moisture always present in concrete, which, on hydration, would expand, the force developed causing, in turn, still further breaking up of the coarse particles and further hydration and expansion, the action continuing as long as there are any particles of cement in condition to break down.

It is known that some clinkers tend to break down and decrepitate more than others. It is also known that cement which has been stored for a considerable period, in the form of clinker, and subsequently aged after grinding, will show less tendency to expansion in the ordinary steam and hot-water tests, as well as in the autoclave.

The possible danger from the presence of the calcium hydrate is probably limited to concrete below the water line. Calcium hydrate is easily decomposed, reacting with the weakest acids; it is soluble in water, and is never found in nature. If, as is generally the case, the hydrate carbonates, no injurious action is produced, as this reaction is accompanied by an increase in specific gravity, and consequently a decrease in volume. If, however, the hydrate enters into other combinations, a marked increase in volume may ensue, and the resulting expansion cause disintegration.

If Mr. Force has developed—as seems probable—in the "autoclave test," a means of readily and quickly detecting in portland cement the presence of these slowly hydrating particles in sufficient quantities to eventually cause disintegration, he has performed a great service for the engineering profession.

We have never been in sympathy with the tendency, referred to editorially in the same issue of ENGINEERING NEWS, to discard all hot-water or boiling tests. We believe the wiser course is, not only to use, but to increase, rather than decrease, the severity of all tests calculated to develop any lack of constancy of volume in the cement. While the large use of concrete demonstrates beyond question its value as a structural material, there are too many concrete structures now showing signs of incipient failure to permit us to relax in any way the demands of the standard specifications, or our efforts to secure improvement in the quality of the cement. If the use of portland-cement concrete is to continue to increase, or even remain as great as at present, the engineer must be assured of its durability. It is unfortunate, perhaps, that the present low prices of cement offer little inducement to the manufacturer to spend more money to improve quality, or to assume the additional cost involved in the storage of the clinker and the finer grinding demanded by Mr. Force. It is an old axiom "that we get only what we pay for," and if the engineer is going to insist, as it seems proper he should, on the furnishing by the manufacturer, for important structures, of a cement which will pass the autoclave test, he should be prepared to offer an advanced price for such a cement.

The problem before the cement manufacturer and engineer is very clearly stated in the following quotation from the Advance Chapter from the Mineral Resources of the United States for the year 1910:

> The use of cement concrete for structural purposes has already become world-wide, and it is increasing at a rapid rate. . . . . Enough time has now elapsed to show that cement concrete alone is not as durable as might be wished, partly because it is not wholly waterproof and partly because the cement either contains free lime or develops free lime within itself after setting. . . . . The problem of waterproofing concrete is being studied from several standpoints, besides that of applying protective coatings; for instance, the endeavor to reduce the voids in concrete to a minimum, as well as to obtain uniformly finely ground cement, and to eliminate the tendency of cement to form free lime in setting. All are absolutely necessary steps in the production of waterproof concrete, and are the special business of the cement manufacturer and engineer of construction to work out.

It is universally recognized that neat portland cement is not durable, and it is for this reason, and not from motives of economy only, that cement is used mixed with sand or other aggregate. Until the cement manufacturers can produce a cement which will be durable when used neat, they should not relax their efforts toward the improvement of their product, and the engineer should not hesitate to adopt, and to insist that the cement shall pass, any test, no matter how severe, that will develop any latent unsoundness or tendency to expand in time after the concrete made from it has hardened on the work. Even though one must pay more for a cement that will meet such special tests than for one that will meet only those required by the standard specifications, the increased cost of the work as a whole will be small, and can be well afforded if it is an insurance against failure or renders it less likely.

A Defectively Maintained Crossing of a railway track and city street makes the city as well as the railway company liable for injuries caused by it, according to a recent decision of the Supreme Court of Indiana. The decision affirmed a judgment for $10,000 against the city of Hammond in favor of a 17-year-old school boy, whose leg was cut off by a freight car. In returning from school the boy caught his foot between a plank and the rail, and he was unable to extricate it in time to avoid being run down.

Suit was brought against both the city and the railway company, the Chicago Terminal Transfer R.R., but the railway company became insolvent and went into a receiver's hands, so that the case against the railway was dismissed, and the jury returned a verdict against the city.

The Supreme Court ruled: The liability of a municipal corporation cannot be evaded because of the statutory duty of a railway company to keep its crossings in a safe condition for travel. The duty of a city to exercise reasonable care to keep its streets in proper condition, or compel a railway company to do so, is a primary duty and cannot be delegated or avoided by any act of the city. The statute only gives the city power to compel a railway company to repair its crossings without expense to the municipality, and failure to exercise this power imposes the liability for any injuries arising therefrom upon the city.

A Conflagration at Chicoutimi, Que., June 24, destroyed the cathedral of that place, the Hotel Saguenay and hundreds of houses. Reports state that the fire started from an overheated stove in the hotel. The property loss is estimated at $2,500,000.

Fire in a Reinforced-Concrete Pulp Mill

By Morton C. Tuttle*

The pulp-board mill of the Androscoggin Pulp Co., located at So. Windham, Me., was built by the Aberthaw Construction Co. in 1906. I. W. Jones, of Milton, N. H., was the engineer. The building is of reinforced-concrete construction except for the roof, which is of wood carried on wooden trusses. The window frames and sashes are of wood. Some time after the building was built, a wood and plaster gallery, the ruins of which are shown in Fig. 3, was built along the side of the mill.

At 11 p.m., May 25, 1912, fire started in scrap paper below the machine-room floor in the main building and set fire to the wooden paneling between the piers forming the outside wall of the lower

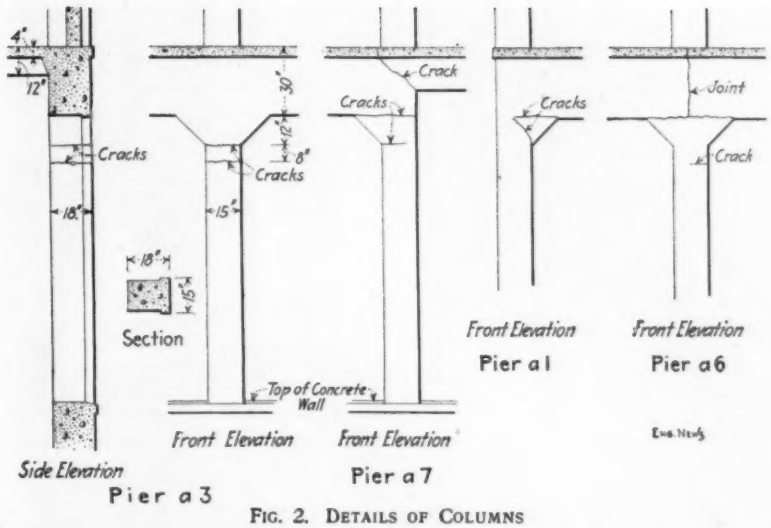


Fig. 2. Details of Columns

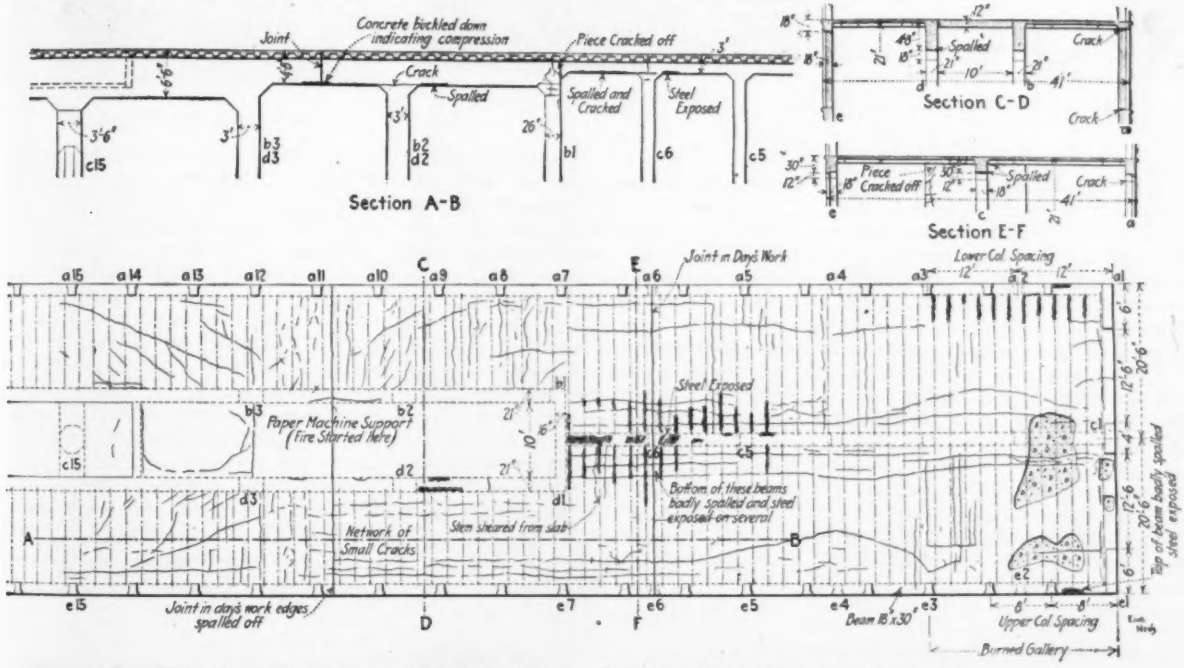


Fig. 1. Plan and Longitudinal Section through Concrete Pulp Mill, Showing Damage by Fire

story of the building. The burning panels set fire to the wooden sash of the windows of the second story, and from there set fire to the roof and to the gallery. There was a large quantity of dry pulp board piled inside the building which burned at the same time. The fire was so hot that it bent and partly melted cast iron. Streams of water were thrown with considerable force, and altogether the fire offered a particularly interesting test of the effect of fire on reinforced-concrete work.

The writer examined the building on May 28 and talked with Seth A. Moulton, of Portland, Me., the engineer in charge of the rebuilding, and is indebted to him

Fig. 3. View of Pulp Mill After Fire
(Burned gallery on opposite bank parallel to river.)

*Secretary, Aberthaw Construction Co., Boston, Mass.

FIG. 4. VIEW OF COLUMN AND UNDER SIDE OF FLOOR AFTER FIRE
(Note exposed rods in girder.)

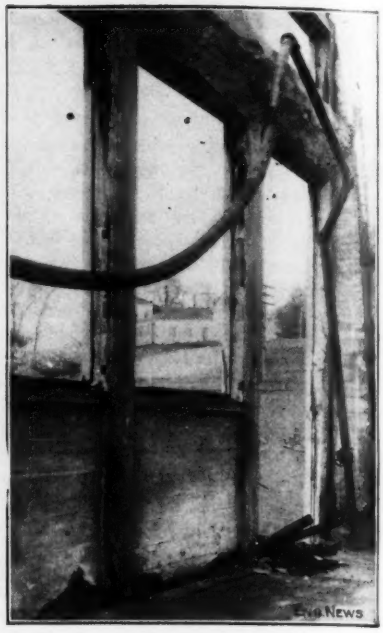


FIG. 5. SPALLED CRANE-RAIL GIRDER

for many of the facts and also for some shrewd suggestions as to the cause of some of the results observed. A few days after this, at the writer's request, J. A. Garrod, the superintendent, and A. B. MacMillan, the engineer of the Aberthaw Construction Co., made a careful investigation, of which this is a report.

The stone used in the concrete on this job was coarse grained crushed granite. The sand was of good quality, and the work was carefully built. The placing of the steel was better done than average.

The fire started under the first floor in the middle of the building (Fig. 1). The principal observable effect of the heat was to expand the floor and to cause a movement of the columns. Mr. Moulton reported that on the morning of the 26th the end wall of the mill was observably out of plumb, and at that time the concrete was generally so hot that he could not bear his hand on it on the outside of the building. Later on this wall drew back again to the perpendicular. The crack at pier marked "A7" (Figs. 2 and 4) shows the effect of this movement on the outside wall, where the size of the wall beam changes on account of the change in spacing of the columns, which are closer together at the river side (right side on Fig. 1). The cracks above and below the bracket of the column also seem to indicate the longitudinal movement of the floor.

The same sort of expansion seems to be indicated by the cracking of the columns at the sides of the building, which was probably caused by the movement of the floor laterally. These cracks occur at both top and bottom of some of the columns. The top cracks are shown in Fig. 2.

Referring to Fig. 1, it will be noticed that in the section of the floor at the wall end of the building (right end) the main cracks run longitudinally and are clearly marked, and that the cracks at right angles to the building are comparatively few. Where the floor span decreases next to the large girders which support the paper machine the cracks begin to run at right angles, and end with diagonal cracks which die away into the part of the floor which was not heated. It is suggested that the cracks at the wall end of the building which are parallel to the main girder occurred because of the unequal heating of the big mass of this girder and the thinner floor slab, causing unequal expansion of the two masses. A similar cause may have produced the crack along the wall beam.

Because there was a considerable amount of water thrown upon light colored pulp and because the under side of the ceiling was blackened by the smoke from the fire, when the water carried the pulp through these cracks in the floor it showed these cracks very clearly on the under side. The cracking of the floor at the end of the paper-machine foundation is shown on cross-section "CD" (Fig. 1).

Fig. 4 shows a detail of the column head and the spalling of the concrete

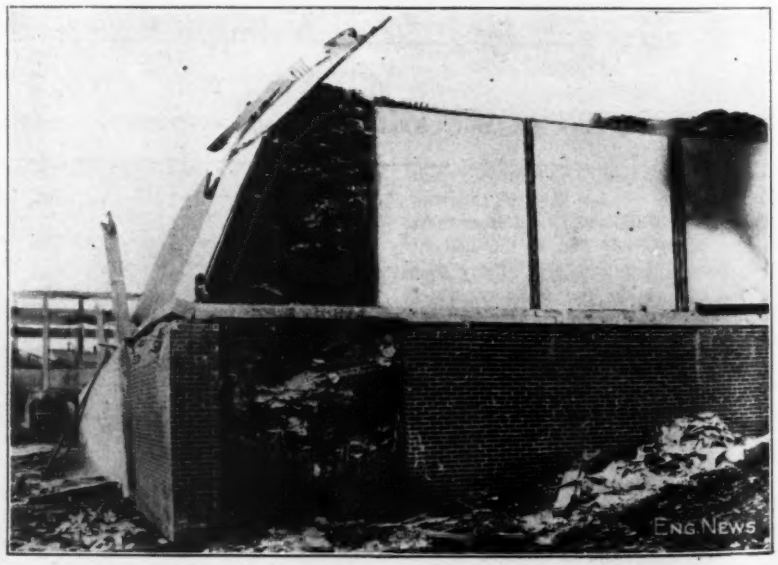


FIG. 6. FAR END OF BURNED GALLERY, LOOKING TOWARD MAIN MILL

under the girder steel. Fig. 5 shows the condition of the crane rail girder after the fire. The concrete was here spalled off about 2 in. in depth. Where the concrete was rich in mortar there was less damage than where it was stony, the mortar acting as a fireproofing to the aggregate. Where the fire was hot the concrete was softened for an average of an inch, so that one could hack into it with an ordinary carpenter's hammer.

At the end of the machine room, in the gallery, there was a stock house built with concrete piers, supporting a wooden floor carried on steel beams, with wooden columns carrying a wooden roof. The walls of the building were "hy-rib" metal. At the base of the building there were some brick walls, being in the condition shown in Fig. 6. The interesting feature that the wall was worthless, these bricks being easily knocked out with a light hammer."

New Passenger Terminal at Vancouver, B. C., Canadian Pacific R.R.

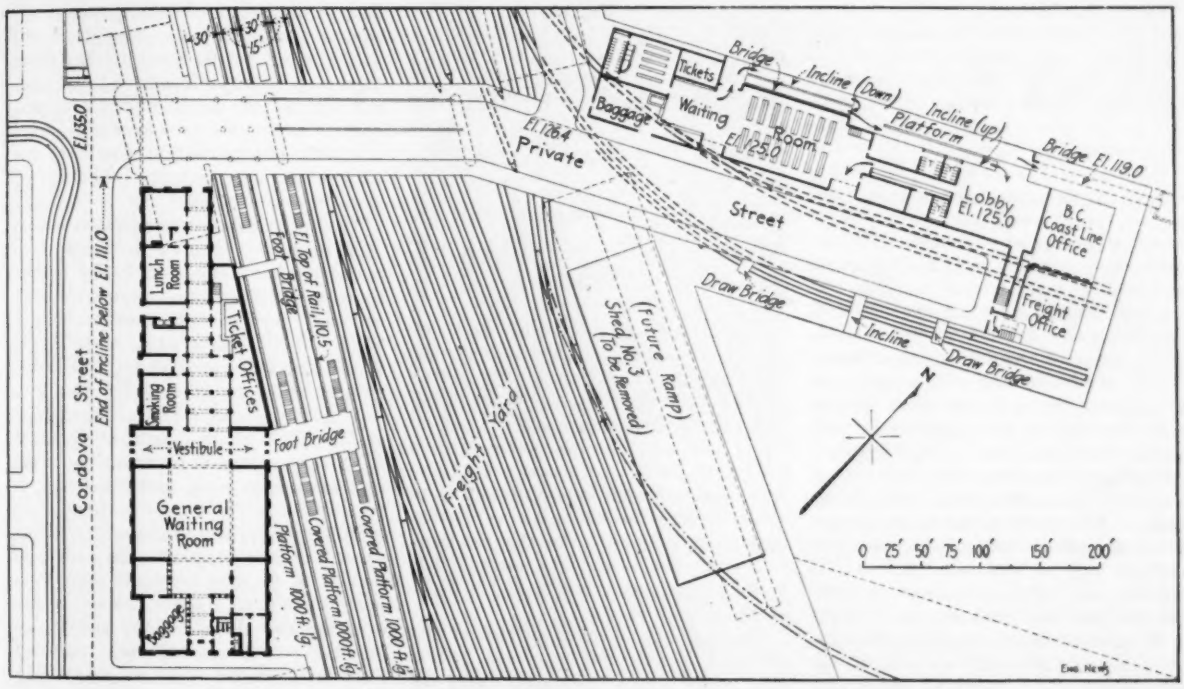
By E. J. Bengler, C. E.*

Plans have been prepared and work is now under way on certain improvements in connection with the Canadian Pacific Ry. passenger terminal at Vancouver, B. C.

The present passenger station of the Canadian Pacific Ry. at Vancouver is located at the foot of Granville St., near the shore line of Burrard Inlet. The station was built about 14 years ago, and station certain of the freight tracks serve the several sheds, and other tracks are used for drilling and storage. The yard tracks extend along the harbor front about 1½ miles.

By reason of its favorable location and the transportation facilities afforded by the enterprise of the Canadian Pacific Ry., Vancouver has grown in about 25 years from a trading camp to a well established city with over 125,000 inhabitants. Situated at the terminal of the first, and still the only, Canadian transcontinental railway line on a fine natural harbor and with other favorable surroundings, there is every indication that its population will be not less than 300,000 at the end of the next decade.

The past growth has rendered inadequate the present facilities for handling



New Passenger Terminal of the Canadian Pacific Ry. at Vancouver, B. C.

of this particular building was that the foundation piers which were subjected to high heat were built of concrete, rich in mortar. This concrete withstood the action of heat much better than did the granite concrete of the main mill.

A letter from the engineer makes the following statement in regard to the brick wall of this building: "Mr. Moulton and the writer examined the brick foundations very carefully two or three times after the fire, and found the main section of the brick wall badly bulged, and the bricks badly cracked on the inside of the building, probably as a result of the intense heat of the burning stock, followed by applications of cold water. The wall was 12 in. thick and the two inside courses of brick were so badly shattered except for minor alterations, is unchanged from its original plan. The general waiting room and ticket offices are at the street level, and the baggage room is on the track level which is about 30 ft. below the street.

Along the water front across the local freight-yard tracks are located the steamship wharves. There are two large sheds on a jetty pier of recent construction used by the Trans-Pacific steamship lines; also five sheds adjoining the longitudinal wharves used by the Seattle, Victoria, Alaska, and other steamship lines of the Canadian Pacific Ry.

Between the wharf sheds and the passenger tracks adjoining the passenger

*Westinghouse, Church, Kerr & Co., New York City.

the terminal business of the railway company, and the general plan shown herewith has been adopted to relieve the present congestion, as well as to provide for reasonable growth in the near future.

The general scheme embraces a passenger station and office building suitably located on available land immediately east of the present passenger station. There will be four passenger tracks with provision for more when required, separated by wide platforms, between the station and the present freight yard. The passenger tracks are to be raised about 5 ft. above the present track level to reduce the difference in level between the street and the tracks to about 25 ft.

In order to avoid an inconvenient grade crossing and delays to traffic between the

city and steamship wharf a bridge on the line of Granville St. extended, is to pass over the passenger and freight tracks to the steamship pier and connect directly with passenger accommodations on the pier. An incline is also to be built leading from the west side of this bridge to the wharf, giving access to the lower deck of the pier and freight sheds, and the water front.

Another viaduct over the tracks is to be built on the line of Burrard St. extended northerly with an incline giving access to the present Trans-Pacific pier and other portions of the water front.

The main entrance of the passenger station will be on Cordova St. with the main waiting room located centrally in the station on the street level. Ticket offices serving the several classes of railway and steamship passengers are located at one end of the waiting room, and the baggage-checking room, lunch and dining room, parcel room, women's waiting room, men's smoking room, news booth, information booth, and other facilities are all placed immediately adjoining the main waiting room.

On the lower floors of the station are located the baggage rooms, express companies' space, immigrant rooms, supply rooms, and other station facilities not directly used by passengers. Stairways and lifts connect the two levels of the station, and also afford communication with the office floors above. A separate footbridge is carried over the passenger tracks directly connected with the waiting room at one end and with stairways leading to the track level, giving access to platforms without crossing tracks at grade.

The track platforms are 1000 ft. in length and are to be covered with shelter sheds of the umbrella type. The platform adjoining the station will be used for baggage, express and supplies.

Above the public rooms of the station building the space will be devoted to the general offices of the railway company. The interior arrangement of the office space will be adapted for a unit system of subdivision; that is, each panel will have heating and lighting facilities so that partitions may be placed or removed at will in order to provide for changes in arrangement of office accommodations which may be desired from time to time.

The proposed steamship station on the pier is a two-level building, the upper floor being devoted to the passenger business and offices, and the lower floor to freight, baggage and express. There will be double-level gangways on the west side of the pier, which will be used for the Victoria and Seattle service, the lower gangway being used for freight, and the upper for passengers; these gangways to be supported on floating pontoons to maintain the landing at a constant level with respect to the boats.

On the passenger, or upper level of the pier, are provided waiting rooms, ticket offices, baggage-checking rooms, customs office, and other conveniences. Separate rooms are provided for outgoing and incoming passengers. Two tracks will be placed on the surface of the pier within the shed, and one track on the outside of the building for the direct handling of freight between cars and steamers.

The essence of the general design has been to secure easy lines of communication between the railway trains, steamers and the city. The traffic conditions at Vancouver are unusual as compared with other large terminals on account of the absence of suburban business. The aggregate number of trains is not large, but they are long and frequently are run in several sections and contain a number of classes of traffic.

The designs for the terminal have been prepared by Messrs. Westinghouse, Church, Kerr & Co., Montreal, Calgary and Vancouver, in coöperation with the officials of the Canadian Pacific Ry., and the construction of the station and facilities is now being carried out by the same organization.

Municipal Progress at Calgary, Alberta

Among the newer cities of the Canadian West which have been making rapid progress during the past few years, Calgary, Alberta, is prominent. In a half dozen years or so its population, according to local censuses, has increased from 6000 to 60,000. This means a great demand for municipal improvements of all kinds, as will be shown by a few figures given later on. The city has gone extensively into municipal ownership, has a city planning commission and a board of city commissioners.

The city laid 33 miles of sewers and 38 miles of water mains in 1911, made 2600 water connections and paved 12 miles of streets. It now has under contract 425,000 sq.yd. of new pavements, 222,000 sq.yd. of concrete sidewalks, two refuse destructors, a 6-ft. outfall sewer, a 2000-yd. municipal asphalt plant, and various other improvements. The pavements under contract include 100,000 yd. of sheet asphalt, 100,000 yd. of Canadian "mineral rubber," 75,000 yd. asphalt-concrete, 50,000 yd. of bitulithic, 25,000 yd. of granitoid and 75,000 yd. miscellaneous. Pavements, sidewalks and sewers (except trunk sewers) are paid for by frontage assessments.

The city has two small garbage furnaces and has under construction two 75-ton 2240-lb. Heenan & Froude refuse destructors. Connected with each of the new furnaces will be two 125-hp. boilers. The steam from one of the boilers will be used to run the new municipal asphalt plant and that from the other will serve, ultimately, to supply heat and power for a proposed sewage-purification plant. Garbage, rubbish and ashes will be collected together.

The sewers are on the combined plan, but separation has been started. The sewage is now discharged into the Bow River, untreated, but plans for purifying the sewage are under consideration. Probably a modified form of Imhoff tanks and sprinkling filters, all covered, with heating in winter, will be adopted. The projected capacity of the plant is 12,000,000 Imp. gal.

The present water supply of 8,000,000 gal. daily capacity, is from the Elbow River, by gravity, from a point 12 miles above the city. An emergency supply is available by pumping from the Bow River. A bond issue of $700,000 has been authorized for an additional gravity water supply of 22,000,000 gal., also from the Elbow River, but from a point two miles higher up than the location of the present intake. A 42-in. wood-stave conduit, 14 miles long, is proposed. Of the $700,000, about $200,000 is allowed for mechanical filters, using sulphate of alumina as a coagulant.

Another evidence of progressiveness at Calgary is the proposal to build three public-comfort stations, estimated to cost $8000 each. These have been authorized and bids for them will soon be invited. They will be underground, about 17x72 ft. in plan, with provision for both sexes, and for both free and paid service.

A unique two-level reinforced-concrete viaduct, 1700 ft. in length, is projected by the city. General plans for the structure have been made and the bylaw to provide funds for its estimated cost of $750,000 was to be introduced in the city council on June 24, 1912. The high-level portion of the viaduct would start from near the top of a bluff and go to and over the Bow River. Each end of the low-level portion would start near the river level, in the form of an inclined approach. Besides the approaches there would be five 100-ft. spans, as compared with the 17 spans of the high level or main portion of the viaduct.

The high-level portion would have a 40-ft. roadway and two 5-ft. sidewalks; the low-level, a 24-ft. roadway and two 4-ft. sidewalks. There would be two tracks for the municipal street railway on the high level.

Calgary is governed by a mayor, a city council of twelve members, and three commissioners, including in the latter the Mayor as an *ex-officio* member. The two appointive commissioners are appointed by the council but their appointment is ratified by popular vote. The two commissioners serve for two years and are paid $4000 a year each. The mayor receives $5000.

The commissioners are the chief execu-

tive officers of the city. The council refers various matters to them for study and recommendation and the commissioners recommend appointments to executive positions. A two-thirds vote of the council is required to override recommendation made by the commissioners. The mayor has no veto power over acts of the city council and he votes in the council on the recommendations made by the commissioners.

Except for bylaws calling for improvements paid for by local frontage assessments, a single dissenting vote in the council defeats a proposed bylaw.

In local affairs the city of Calgary enjoys a large measure of home rule. The city commissioners' plan now in force was adopted by the voters, independently of the provincial legislature.

The City Plan Commission was created last February. It is a large body of 34 members, appointed by Mayor Mitchell, on authority of the city council, and serving as advisory to the council. The commission was given $3000 for its first year's work, including the salary of a permanent secretary. The city council has gone on record as in favor of a civic center and the commission has secured competitive sketches from ten men, located in Canada, Great Britain and the United States. The commission hopes and expects to be given authority to engage an expert to make final plans for a civic center and for a broader city planning scheme.

No small part of the growth of Calgary is due to the Canadian Pacific Railway and particularly to its Department of Natural Resources and the immense irrigation works built and now being extended under the direction of that department.

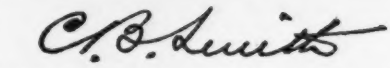
A lengthy illustrated description of these irrigation works, which will serve more than 800,000 acres of land, was published in our issue of Apr. 27, 1905. Since then the project has been carried forward to completion in some of its parts and much new work has been put under way. Notes on the present status of the project will be published in a later issue.

J. T. Child is city engineer of Calgary. J. S. Davidson is chairman, and G. W. Lemon is secretary of the city planning commission.

Granite Asphaltic Macadam on a crushed limestone base is being laid at Minneapolis, Minn. The first layer of granite is coated with asphalt in a machine mixer, spread and rolled. Smaller granite is then applied and asphalt poured over it. Screenings and sand are added and the whole is rolled. The asphalt is a petroleum residue. This and other paving work is done by day labor. Andrew Rinker is city engineer of Minneapolis and Ellis Dutton is assistant engineer in charge of pavements.

Cecil Brunswick Smith*

As briefly noted in our obituary column of last week, Cecil Brunswick Smith, one of the most active and prominent engineers of Canada, died at his home in Toronto, Ont., on July 1. Two weeks before, Mr. Smith had been engaged in his customary professional activities on the Pacific coast. At that time he consulted a specialist in California who warned him that he was suffering from an internal cancer and had not long to live. He returned to his home in Toronto, in accordance with his physician's instructions, to close up his affairs as soon as possible. Until the specialists' examination Mr.



Smith had had no knowledge of his serious malady.

Cecil Brunswick Smith was born at Winona, near Hamilton, Ont., 48 years ago. He was educated at the Collegiate Institute at Hamilton and the School of Applied Science of McGill University, Montreal, Que., where he graduated in civil engineering in 1884, when but 19 years of age. For his high standing in scholarship he was awarded the Governor General's Gold Medal for that year.

Following his graduation Mr. Smith was Resident Engineer on construction of the Nipissing & Pacific Junction Ry., now part of the Grand Trunk Ry. system, and later of the St. Catharines & Niagara Central Ry. From 1887 to 1888 he was Resident Engineer on the construction of the Canadian Pacific Ry. between Woodstock and Windsor, Ont.; and for a year he was Locating Engineer of the Toronto, Hamilton & Buffalo Ry.

After two years in the United States spent as Division Engineer and Chief Assistant Engineer of railways constructed in North and South Carolina, Virginia and Maryland, he returned to Canada to become Assistant Professor of Civil Engineering at McGill University, a position he continued to hold for five years, until 1898. During this period Prof. Smith made a special study of the characteristics of portland cement and was the author of several papers dealing with this subject. He also wrote a textbook on railway engineering.

In 1898 Mr. Smith was appointed Locating Engineer of the Canadian Pacific Ry. on a short line between Toronto and Sudbury, Ont. The following three years he served as Assistant City Engineer of Toronto. In 1901 he was appointed Resident Engineer on construction for the Canadian Niagara Power Co., and between 1901 and 1905 built the present plant of that company at Niagara Falls, Ont. At the close of this work Mr. Smith became Chief Engineer of the first Hydro-Electric Power Commission of the Province of Ontario and organized the very complete water-power surveys which were conducted in 1906 and 1907. The reports of this work have formed the basis of all water-power developments in the Province since.

During the same period Mr. Smith also served as Chairman and Consulting Engineer for the Temiskaming & Northern Ontario Railway Commission. In 1907 he retired from both commissions and established the firm of Smith, Kerry & Chace, consulting engineers, of Toronto. As senior member of this firm, Mr. Smith has had the supervision of planning and constructing some of the largest hydro-electric power plants in the Northwest, among them the 60,000-hp. development on the Winnipeg River, near Winnipeg, Man.; the 19,000-hp. plant for the Calgary Power Co., on the Bow River in Alberta; the 24,000-hp. development of the Mount Hood Ry. & Power Co., near Portland, Ore., and the 15,000-hp. plant on the Snake River in Idaho for the Crane Falls Power & Irrigation Co.

Mr. Smith served these enterprises not only in an engineering capacity but largely directed their organization and financing. In this connection he served as President, Manager or Vice-President of several of these large development companies.

He was ever active in promoting the welfare of his profession and was a member of the Institution of Civil Engineers of Great Britain, of the Canadian Society of Civil Engineers, of which he was a member of the Council and a Past Vice-President; the American Society of Civil Engineers, the Engineers' Club of Toronto and the Oregon Society of Civil Engineers.

Mr. Smith was one of the busiest of men, and his early death may perhaps be attributed in some degree to the pressure

*From data furnished by J. G. G. Kerry, of Smith, Kerry & Chace, Toronto, Ont.

under which he worked, taking him back and forth across the continent many times in the course of a year. It was a well considered plan of his to retire to a strictly consulting practice as soon as the last of the great works which he had under way was completed; but apparently he had miscalculated his strength and was denied the termination for his career, which he had so earnestly desired.

Mr. Smith is survived by a widow and two sons.

A Powder Mill Explosion, June 30, at the Du Pont Powder Co.'s plant near Haskell, Okla., caused the death of one man and the injury of another. Reports state that 1000 cans of nitroglycerin exploded. Many windows were broken at Haskell, 2½ miles distant.

A Locomotive-Boiler Explosion in Mexico, June 28, is reported to have killed seven persons and seriously injured three others. The accident occurred on the National Ry. of Mexico at Puente del Saltillo.

A Locomotive Boiler Exploded, June 26, on the Southern Pacific Ry., near Hondo, Tex. The engineer was killed and the fireman badly injured. The accident occurred at 2:15 a.m. while the train, a regular westbound freight, was under way. Press reports ascribe the explosion to low water in the boiler and state that the manner of failure was in many respects similar to that of the locomotive-boiler explosion in the Southern Pacific yards at San Antonio, Tex., Mar. 18.

A Grade-Crossing Accident in Spain, July 3, caused the death of five persons and the injury of 25 others when a railway train collided with a street car at El Drao.

A Grade-Crossing Accident in Germany, June 30, near Breslau, in Prussia caused the death of eight members of a picnic party, who were being driven across the railway track in a wagon. Reports state that the wagon was struck by an express train moving at full speed.

Lightning Demolished a Threshing machine, June 29, on a farm eight miles north of Racine, Wis. Reports state that five men were killed and that a fire, started by the lightning flash, completely destroyed the threshing outfit, together with a large barn.

A Defective Rail has been found to have caused the accident on the Great Northern R.R., near Sharon, N. D., Dec. 30, 1912, in which five persons were killed and 18 others injured, according to the report recently given out by the Interstate Commerce Commission. The rail in question was of Bessemer steel, and weighed 80 lb. per yd. It is described as primarily defective and seriously seamed and split.

A Stone Crusher Platform Collapsed, July 1, at Kenogami, Que. Seven men at work under the platform were killed. Reports state that the stone crusher was being used by the Canadian Stewart Co., which is erecting the large pulp mill for the Price Bros. Co.

A Butting Collision Between Two electric cars on the Marion, Bluffton & Eastern Ry., July 7, caused the death of three persons and the serious injury of 10 or 12 others. The collision occurred on a stretch of straight track, near Marion, Ind.

A Butting Collision Near Ligonier, Penn., July 5, on the Ligonier Valley R.R. caused the death of 26 persons and the injury of 40 others. Most of the victims were passengers on the one car of a train which was running backward from Ligonier to Wilpen. This train collided with a freight pulled by two locomotives. The passenger coach was crushed to pieces between its own locomotive and those of the freight train.

According to press reports, it was the regular practice to cut off the combination baggage and smoking car of the regular train from Latrobe, Penn., to Ligonier and then back out with the single passenger coach along the Wilpen branch of the railway. The accident took place on a curve, and is ascribed to a misunderstanding of orders.

A Disastrous Rear Collision, July 4, on the Delaware, Lackawanna & Western R.R. at Gibson, near Corning, N. Y., caused the death of 39 persons and the injury of some 50 others. The drawhead of one of the cars of a freight train pulled out on the grade near Gibson. Passenger train No. 9, which had left Hoboken at 9 p.m. the night before, was brought to a stop behind the freight train. This was at about 5 a.m. While one of the two locomotives of train No. 9 was trying to push the broken freight train up the grade, express train No. 11 came up and crashed into the rear of No. 9. It is stated that the express train, which was made up of a heavy locomotive hauling ten loaded express cars, was running 65 miles per hour.

The two rear cars of train No. 9 were day coaches, and they were both telescoped by the locomotive of the express. The third car from the rear was a steel Pullman, and the locomotive came to a stop after crumpling up the end of this car. Reports state that only four of the persons killed were in this Pullman, the other victims being in the two rear day coaches.

According to the best information now available, the accident was due to failure to observe signals on the part of the engineer of the express train. It is claimed that he ran by three signal lights: the block signal at the distant end of the block behind the passenger train, which was set at "caution"; the fusee lighted by the passenger train's flagman, and finally the block signal set at danger a few hundred feet behind the passenger train. The length of the block between the two signals was 4500 ft. It is claimed that the flagman had stationed himself between these two signals at a distance of about 2000 ft. from train No. 9. The engineer of the express train is expected to survive his injuries, but is not yet in a condition to bear examination.

A Flywheel and Boiler Explosion, on July 6, wrecked the first story of the National Sulphur Works, in Williamsburg, New York City. Twelve men were injured, one probably fatally. Reports state that a 200-ton flywheel in the engine room burst and that a piece of the wheel was thrown against one of the boilers, causing it to explode.

The Rainfall in the Vicinity of Boston, Mass., during the month of June was the least for any month since the Weather Bureau was established there in 1871. But 0.27 in. of precipitation occurred during the whole month, and 0.24 in. came in one day, June 6. The nearest low record is September, 1884, with 0.31 in. of rainfall.

Bubonic Plague has made its appearance in San Juan, Porto Rico. The situation, although serious, is said not to be dangerous, as effective measures were taken at once to exterminate rats and otherwise clean up the infected districts. There have been about 10 deaths among the native inhabitants, due to the plague. During the past week the plague has also appeared in Havana, Cuba, although but one case was reported up to July 7. A rat extermination campaign is also being waged there.

An Order Regulating Gas Pressures has been served by the Public Service Commission of New York City upon the companies furnishing gas in the Borough of Manhattan. The order stipulates that the pressure at the consumer's end of the company's service pipes shall never be less than 2 in. of water column. An extended investigation has shown that the pressure at the end of the service pipes has generally been less than this, and frequently less than 1½ in.

The order provides further that on and after July 1, 1913, the maximum daily pressure variations, independent of momentary and pulsating variations in pressure, shall not exceed 3 in. of water column on any two consecutive days. After July 1, 1914, the daily pressure variation is specified not to exceed 2½ in., and after July 1, 1915, not to exceed 2 in. water column on two consecutive days. Regulations are also prescribed as to the maximum momentary pressure variation and the maximum pulsating pressure variation after July 1, 1913.

The Commission has been assisted in its extensive investigation of gas pressure conditions by William A. Baehr, a consulting gas engineer of Chicago. The Commission has indicated its intention of carrying the investigation subsequently into the other boroughs of the city.

The New York State Barge Canal work is only about 60% completed, according to the figures given in the "Barge Canal Bulletin" for June, 1912. This bulletin gives a list of all contracts, with their total value, the amount paid out on them up to June 1, 1912, and the percentage of the work done upon each contract up to the same date. An average of the last figures for 93 contracts on the main branches of the Canal, excluding the Cayuga and Seneca side line, shows 63.5% of the work completed. An average of the ratios of amounts paid out to total contract values for the same contracts equals 60.6%. As the total under contract is only $73,000,000, and as $101,000,000 is available, it is evident that the estimate of 60% completion is not too high. Work on the Canal has now been in progress for seven years. At the present rate then it will not be completed much before the navigation season of 1917.

A Federal Patent Investigation Commission was urged by the Inventors Guild at a meeting held in New York, May 31, at which the following resolution was adopted:

The Inventors Guild does hereby by unanimous vote give expression to its unqualified endorsement of the policy of President Taft looking to the appointment of a Commission to thoroughly investigate the intricate and important subject of Patent reform before the passage of legislation. And the Inventors Guild respectfully makes the suggestion that such a Commission should be one upon which there should be representatives of all important interests affected by the Patent System, such as the general public, the inventors, the manufacturers, the courts, and the patent law-

versy and that the general public should have the greatest number of representatives upon the Commission, inasmuch as modifications in the Patent Laws and Court procedure should be made only in order to promote the general welfare of the United States, regardless of the interests of special classes, such as inventors, manufacturers, Court officials, patent lawyers, etc.

The President of the Inventors Guild is Mr. Ralph D. Mershon, who has just been elected President of the American Institute of Electrical Engineers.

Plans for an International Engineering Congress to be held in connection with the San Francisco Exposition in 1915, have been under consideration for some months by committees organized from the engineers resident on the Pacific Coast and representatives of the national engineering societies. The plan now favored is to have such a congress conducted by an independent organization made up of representatives of the several national engineering societies elected chiefly from the Pacific Coast membership. In order to finance the congress, a guarantee fund is being raised in San Francisco, and it is expected will be supplemented by underwriting agreements on the part of several of the national engineering societies. It is proposed to make membership in the congress open to any engineer at the price usually charged for participation in international engineering congresses in Europe, $5, which sum would entitle the subscriber to attend the congress, take part in its proceedings and receive the volumes of the congress proceedings when finally published. It is believed that if conducted on this basis, the revenues from membership subscriptions would pay a large part of the expense of printing and publication, which is the chief item of cost in conducting such a congress.

A Moving-Platform Subway Line has been laid out in New York City by the Public Service Commission. It is to be a crosstown line on 34th St., from Second Ave. to Ninth Ave., a distance about one mile east and west. The end portions are to form loops, the easterly loop extending through 34th St., Second Ave., 35th St. and Third Ave. to the corner of 34th St. and Third Ave., while the westerly loop, beginning at a point in 34th St. between Eighth and Ninth Aves. passes under 34th St., Ninth Ave. and private property to the point of beginning. The route has been laid out as a result of the proposals of the Continuous Transit Securities Co. (M. E. Schmidt, Pres.), which company has been promoting moving-platform proposals in New York City for a number of years past, hitherto without success. In order to provide against the risk of failure of the moving-platform method of operation, the Public Service Commission's resolution laying out the route provides that it may be operated "either by moving platforms or by separate cars or trains, or by any other device or means in the construction of which stationary means for guiding a conveyance in a definite path and means for propelling such conveyance are necessary elements." In this way the resolution will also cover operation by ordinary rapid-transit trains if this is considered necessary after trial of the moving-platform method.

The proposed moving-platform line will pass through one of the busiest parts of the city, crossing seven north-and-south rapid transit lines (four elevated lines, three subway lines) and ten north-south street-car lines. At Broadway it will be within one-half block of the present northern terminus of the Hudson Tunnel system, which communicates with Hoboken and Jersey City and indirectly with the lower part of New York City. At Seventh Ave. it will be within one block of the Pennsylvania R.R. station. The 34th St. district at present contains half a dozen large department stores, and shopping business has in recent years concentrated in this region very strongly. The present theater district extends north from 34th St., and the principal hotels of the city are grouped along Broadway in this neighborhood.

Employees of the Pennsylvania R.R., who have been in the service of the company for more than 40 years, number 3612; of these 2040 are still in active service, while 1572 are on the pension rolls. One man has served this railway for 66 consecutive years, and 489 have served more than 50 years. There are nearly 5000 employees whose ages range from 60 to 70 years. Eight pensioners are over 90 years old. Of the 178 officers included in the company's official biographical list, 171, or 96%, have been with this railway all their business life. Eighty-four, or about half of them, are college men. Seven of the instances where officers have not been with this company all their business careers include such positions as required special training, which the company did not offer.

Personals

Mr. L. N. Gillis, of Washington, D. C., has been appointed Consulting Engineer of the Consolidated Conveyor Co., of Washington.

Mr. Ralph D. Mershon, consulting engineer, of New York City, has been elected President of the American Institute of Electrical Engineers.

Mr. George E. Pellissier, Assoc. M. Am. Soc. C. E., has resigned as Chief Engineer and Superintendent of the Goldschmidt Thermit Co., of New York City.

Mr. J. M. Doyle, Assistant Superintendent of the Great Northern Ry., at Marcus, Wash., has been promoted to be Superintendent, succeeding Mr. R. C. Morgan, resigned.

Mr. John W. Tumbridge, of Brooklyn, N. Y., has been appointed Superintendent of Highways of the Borough of Brooklyn, New York City, succeeding the late Fred Linde.

Mr. H. T. Douglas, Jr., formerly Chief Engineer of the Wheeling & Lake Erie R.R., has been appointed Chief Engineer of the Chicago & Alton R.R., succeeding the late W. D. Taylor.

Mr. Arthur B. Wollaber, for a number of years in charge of the United States Weather Bureau at Los Angeles, Calif., has resigned to accept a position with the Southern California Edison Co.

Mr. George Henry Benzenburg, Past-President, Am. Soc. C. E., consulting engineer, of Milwaukee, Wis., was awarded the honorary degree of Doctor of Engineering by the University of Michigan, on June 27.

Mr. Cornelius Donovan, M. Am. Soc. C. E., Principal Assistant Engineer, U. S. Engineer Office, New Orleans, La., was awarded the honorary degree of Doctor of Engineering by the University of Michigan, on June 27.

Mr. H. W. Rhodes, for a number of years Assistant in the United States Coast and Geodetic Survey, has been appointed Inspector of the 18th lighthouse district, with headquarters at San Francisco, Calif.

Mr. George Jacob Davis, Assoc. M. Am. Soc. C. E., Assistant Professor of hydraulic engineering at the University of Wisconsin, has resigned to become Dean of the college of engineering at the University of Alabama.

Prof. William Leslie Hooper, M. Am. Inst. E. E., head of the department of electrical engineering at Tufts College, Medford, Mass., has been elected Acting President, succeeding Dr. Frederick W. Hamilton, resigned.

Mr. Patrick J. Carlin, President of the P. J. Carlin Construction Co., New York City, has been appointed Superintendent of Buildings of the Borough of Brooklyn, succeeding the late John Thatcher, who was killed recently by a fall.

Mr. H. K. Drayton, Corporation Counsel for the city of Toronto, Ont., and a member of the Toronto Hydro-Electric Power Commission, has been selected to be Chairman of the Dominion Railway Commission, succeeding the late Hon. J. P. Mabee.

Mr. R. H. Goddard, connected with the engineering work of the United States Bureau of Lighthouses for the past 20 years, has been promoted to be Inspector of the second lighthouse district at Boston, Mass., succeeding Mr. E. C. Gillette, promoted, as noted elsewhere.

Mr. E. W. Scheer, formerly Assistant Secretary of the Baltimore & Ohio Southwestern R.R., has been appointed Assistant to the General Superintendent of the Baltimore & Ohio Southwestern R.R. and the Cincinnati, Hamilton & Dayton R.R., with headquarters at Cincinnati, Ohio.

Mr. L. R. Johnson, M. Can. Soc. C. E., formerly Assistant Superintendent of Motive Power of the Canadian Pacific Ry., at Montreal, Que., has been promoted to be General Superintendent of the Angus shops district. He is succeeded at Montreal by Mr. H. Osborne, formerly Superintendent of the Angus locomotive shops.

Mr. James N. Hill has resigned as Vice-President of the Northern Pacific Ry. Mr. Hill is a son of Mr. James J. Hill, who retired as Chairman of the board of directors of the Great Northern Ry., on June 30. Mr. Louis W. Hill, who recently resigned the presidency of the Great Northern Ry., has succeeded his father as Chairman of the board of directors.

Mr. J. S. Conway, Assoc. M. Am. Soc. C. E., formerly Chief Constructing Engineer of the United States Bureau of Lighthouses, has been promoted to be Deputy Commissioner of the Bureau of Lighthouses, vice Mr. A. V. Conover, resigned. Mr. Conway is succeeded as Chief Constructing Engineer by Mr. H. B. Bowerman, former Assistant Engineer. Mr. E. C. Gillette, formerly Lighthouse Inspector at Boston, Mass., has been promoted to be Assistant Engineer, at Washington, D. C., succeeding Mr. Bowerman.

Mr. Joseph T. Yates, for a number of years superintendent in the Tompkinsville, N. Y., district of the United States Bureau of Lighthouses, has been promoted to be Inspector of the third lighthouse district, with headquarters at Tompkinsville. This district includes the coasts of Rhode Island, Connecticut, New York and New Jersey, and is the most important in the service. In addition to

the engineering work of placing and maintaining aids to navigation, the duties of Inspector also include the supervision of a shop employing 250 men, where much of the special apparatus used by the Lighthouse Service is made and repaired.

Mr. Lockett G. Coleman, formerly Assistant Superintendent of the Grand Trunk Ry. at Belleville, Ont., has been promoted to be Superintendent of the Ottawa division at Ottawa, Ont., succeeding Mr. Morley Donaldson, M. Can. Soc. C. E., who has been made Vice-President and General Manager of the Grand Trunk Pacific Ry., as noted in our issue of June 27. Mr. Coleman was educated at Harvard University, and began railway work in 1900 on the Grand Trunk Ry. Later he was employed on the Delaware, Lackawanna & Western R.R., and by the Rogers Locomotive Works; he returned to the Grand Trunk Ry. in 1902 as Trainmaster.

Messrs. Charles F. Uebelacker, M. Am. Inst. E. E., Charles N. Black, Assoc. Am. Inst. E. E., formerl Vice-President and General Manager of the United Railroads, San Francisco, Calif., and William von Phul, M. Am. Soc. M. E., have been admitted to partnership with Ford, Bacon & Davis, Engineers, of 115 Broadway, New York City. Mr. Uebelacker is a graduate of Princeton University, and previous to his association with the firm in 1899, was Chief Engineer of the Short Electric Ry. and the Brush Manufacturing Co., of Cleveland, Ohio. Electrical Engineer of the Consolidated Traction Co. of New Jersey, and Chief Engineer of the Peckham Truck Co., Kingston, N. Y. Since 1902 he has been Chief Engineer of the firm. Mr. Black is also a Princeton graduate, and previous to 1899 was Superintendent of the Brush Manufacturing Co., of Cleveland, Ohio, and Manager of the New Haven works of the Westinghouse Electric & Manufacturing Co. From 1899 to 1902 he was Chief Engineer of the firm of Ford, Bacon & Davis. Since then he has been with the street railway companies of Kansas City, Mo., and San Francisco, Calif. Mr. von Phul is a graduate of Tulane University. For a number of years he was General Superintendent of the Louisiana Electric Light Co. and of the Edison Electric Co., of New Orleans, La. He was also General Superintendent of the Cincinnati Gas & Electric Co., Cincinnati, Ohio. He has been connected with the engineering force of the firm since 1905.

Obituary

Donald Dean Colvin, Assoc. M. Am. Soc. C. E., Engineer of maintenance-of-way of the National Rys. of Mexico, was drowned, on July 2, in a washout on the Guadalajara branch.

Charles W. Smith, a former official of various Western railways, died recently, at his home in Pasadena, Calif. He was born in Columbia County, N. Y., in 1831. His railway career began in 1855 as local agent of the Columbus, Piqua & Indiana R.R. After several years' experience with early railways in the Central West he was made General Manager of the Indianapolis, Bloomington & Western Ry. Later he was General Manager and Vice-President of the Chesapeake & Ohio Ry. In 1886 he went West as General Manager of the Atchison, Topeka & Santa Fé Ry., and from 1887 to 1889 was General Manager of the Atlantic & Pacific Ry. He retired from active work in 1903, after serving for a number of years as President of the Los Angeles & Pasadena Electric Ry.

John A. Pettigrew, for many years Superintendent of Parks of Boston, Mass., died, at his home in Boston, on July 2. He was born in Newcastle, England, in 1844, and came to this country in 1865, settling in Chicago, Ill. Here he became Superintendent of Parks and had much to do with beautifying Lincoln Park and the lake shore front boulevard. From Chicago he went to Milwaukee, Wis., where he did similar work in laying out Milwaukee Park. He next went to Brooklyn, N. Y., to take charge of Prospect Park, one of the most beautiful city parks in America. Mr. Pettigrew went to Boston, Mass., in 1897 to become Superintendent of Parks of that city. He was one of the most notable authorities on park matters and was consulted by municipalities both in this country and Europe.

Arthur Powis Herbert, M. Am. Soc. C. E., a railway engineer of long service in Mexico and South America, died from apoplexy, at his home in Colima, Mexico, on June 16. Mr. Herbert began his engineering work on the Colorado Central R.R. in 1872, when he was 17 years old. He was one of the engineers who went to Brazil in 1877 to build the famous Madeira & Mamore R.R., the adventures and hardships of whom are graphically related in Mr. Craig's book, "Recollections of an Ill-fated Expedition to the Headwaters of the Madeira River in Brazil," published in 1907.

In 1880 Mr. Herbert joined one of the first parties of American engineers to enter the employ of the Mexican National Construction Co. (Palmer-Sullivan concession). With the exception of about a year spent on the construction of an extension of the Oroya R.R. at Cerro de Pasco, Peru, the remainder of his life was spent in Mexico, where he located and built several important railways for Mexican National and Mexican Central companies. After locating and building the Colima division of the Mexican Central Ry. he was made Superintendent of that division, which position he held for nearly 20 years, until the Colima division was merged with other divisions and the position abolished.

Mr. Herbert was a locating engineer of wide experience and good judgment. His genial disposition, impartiality and integrity made him universally liked and esteemed by superiors, associates and subordinates. He leaves a widow and one daughter. (Contributed by Casper W. Haines, M. Am. Soc. C. E., 322 Arcade Bldg., Philadelphia, Penn.)

Engineering Societies

COMING MEETINGS

OHIO ELECTRIC LIGHT ASSOCIATION.
July 16-19. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 26-30. Annual convention at Peoria, Ill. Secy., Clarence R. George, Houston, Tex.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. car shops, East Buffalo, N. Y.

INTERNATIONAL CONGRESS FOR TESTING MATERIALS.
Sept. 2-7. Sixth congress at New York City. Secy. of organizing committee, H. F. J. Porter, 29 West 39th St., New York.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.
Sept. 4 at Washington.
Sept. 6-13 at New York City. Secy., Bernhard C. Hesse, 25 Broad St., New York.

NEW ENGLAND WATER WORKS ASSOCIATION.
Sept. 18-20. Annual convention at Washington, D. C. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 18-20. Annual meeting at Washington, D. C. Secy., Selskar M. Gunn, 755 Boylston St., Boston, Mass.

American Society of Heating and Ventilating Engineers—The program of papers to be presented at the semi-annual meeting, in Detroit, Mich., July 11-13, is as follows:

July 11, a.m.—"Temperature Equivalents of Wind Velocities," H. W. Whitten, Boston, Mass.; "Open Windows in Mechanical Ventilation," Ralph C. Taggart, New York City; "The Time Element in Heating Apparatus," James A. Donnelly, New York City. July 11, p.m.—"Office Practice in Estimating Heating and Ventilation," John D. Small, Chicago, Ill.; "Methods of Automatic Humidity Control for Air Washers," J. I. Lyle, New York City; "Humidity in Relation to Heating and Ventilation," L. C. Soule, Chicago, Ill.; "Brick Drying," H. C. Russell, Washington, D. C. July 12, a.m.—"Removal of Refuse and Waste by Fans and Blowers," F. R. Still, Detroit, Mich.; "Heating and Ventilation of a Mitten Factory," Samuel R. Lewis, Chicago, Ill.; "Heating and Ventilating the Northwestern University Buildings," J. M. Stannard, Chicago, Ill.

International Congress of Hygiene and Demography—The 15th congress, which is to be held under the auspices of the Government of the United States at Washington, D. C. Sept. 23-28, is organized in nine sections as follows: Section 1, Hygienic Microbiology and Parasitology; 2, Dietetic Hygiene and Hygienic Physiology; 3, Hygiene of Infancy and Childhood—School Hygiene; 4, Industrial and Occupational Hygiene; 5, Control of Infectious Diseases; 6, State and Municipal Hygiene; 7, Hygiene of Traffic and Transportation; 8, Military, Naval and Tropical Hygiene; 9, Demography.

Among the very many papers announced in a recently issued program are the following: Section 4—"Diseases and Accidents of Miners and Tunnel Workers," Dr. Wilhelm Lindermann, Bochum, Germany; "Preventive Apparatus and Safety Devices Against Industrial Accidents," Paul Weiss, Paris, France. Section 6—"Sewage Disposal by Dilution, with Special Reference to Conditions in Tidal Waters and Large Streams," Dr. W. E. Ademey, Dublin, Ireland; "Methods of Sludge Disposal," Dr. Karl Imhoff, Bredeney bei Essen, Germany; "The Present Status of the Problem of Ventilation," C.-E. A. Winslow, New York City. Section 7—"A Further Study of the Ventilation of Sleeping Cars," Dr. T. B. Crowder, Chicago, Ill.; "Care for the Physical and Mental Welfare of the Personnel of the Railway," Dr. C. Daye, Stettin, Germany; "Sanitation of Street Cars," J. C. Halleck, Newark, N. J.; "Measures for the Disinfection of Vehicles and Railway Carriages," Dr. Wagner, Berlin, Germany. Section 8—"Administration Methods and Results Obtained in the Canal Zone," Col. W. C. Gorgas, Ancon, Canal Zone.